

CONFERENCE HANDBOOK



Farming the Waters for People and Food

22 - 25 September 2010

Mövenpick Resort and Spa

Phuket, Thailand

Organised by



**Conference Handbook With
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Objectives and Expected Outcomes

Reflecting on the progress made in developing aquaculture as a sustainable food producing sector through two milestone events beginning from the Kyoto Conference in 1976, and 25 years later during the Conference on the Third Millennium in 2000, the *Global Conference on Aquaculture 2010* brings together a wide-ranging group of experts and important stakeholders to take stock of aquaculture's progress and further potential, as basis for positioning the sector and its agenda to the global community.

The aims of the Conference are to:

- Review the present status and trends in aquaculture development.
- Evaluate the progress made in the implementation of the *Bangkok Declaration and Strategy on Aquaculture Development Beyond 2000*.
- Address emerging issues in aquaculture development.
- Assess opportunities and challenges for future aquaculture development.
- Build consensus on advancing aquaculture as a global, sustainable and competitive food production sector.

In order to achieve these objectives, the conference is structured into four dynamic sessions over three days. The conference will be informed by two keynote addresses, six plenary lectures, and three invited guest lectures. To facilitate global understanding of the current status of aquaculture development and the numerous issues facing the sector, six regional reviews on aquaculture development in the past decade and a global synthesis will be presented, followed by 22 expert panel presentations covering six broad thematic areas on key aspects pivotal to aquaculture development, management and sustainability in the coming decades. These include: (i) resources and technologies for future aquaculture, (ii) sector management and governance, (iii) aquaculture and the environment, (iv) responding to market demands and challenges, (v) improving knowledge, information, research, extension and communication in aquaculture, and (vi) enhancing its contribution to food security, poverty alleviation and rural development.

A poster session will enable participants to present technical and experience papers and interact with experts and stakeholders. This and four side events will provide a platform to bring together various stakeholders to discuss important issues pertaining to aquaculture development in the next decade. The conference will be concluded with a plenary presentation of a Draft Consensus and Strategy for Global Aquaculture Development.

The global community is welcome to participate and share responsibility in making aquaculture a sustainable food producing sector.

Conference Organisation

The need to have a follow-up conference to Aquaculture in the Third Millennium held in Bangkok, Thailand, February 200, was conceived at the 19th NACA Governing Council Meeting held in February 2008, Kathmandu, Nepal. This idea was almost immediately followed up by NACA in conjunction with the Department of Fisheries and Aquaculture of the Food and Agriculture Organization and the Department of Fisheries, Royal Government of Thailand, when interim organisational committees were set up, and the idea communicated on the respective web sites of these organisations. Key committees were constituted to ensure that the representation was spread across globally, and be representative, as much as possible of all the regions, expertise and regional and national organisations. The conference is the efforts of these coming to fruition.

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Sloans Chimatiro (NEPAD)

Sena S. De Silva (NACA)

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Nanthya Unprasert (DoF Thailand)
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Waraporn Prompoj (DoF Thailand)
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Secretariat: Network of Aquaculture Centres in Asia-Pacific (NACA)

The Arduous Road from Kyoto 1976 to Bangkok 2000 and Now to Phuket 2010: Milestones in Modern Aquaculture Development

Perhaps the old Chinese proverb, “Teach a man how to catch fish and he will have food for a day, and teach him how to grow fish and he will have food for life” cannot be any truer than now. In the modern era the impetus on fish farming was triggered by the dawning of the gradual realisation that the oceans were bountiful but its biological resources exhaustible and the world will have to look for ways and means of meeting the short fall in food fish supplies, for a growing human population, further exacerbated by the realisation of the human nutritional benefits that fish offer. We believe that aquaculture has achieved what it has to date, in a relatively short time span for a primary production sector, because of a few crucial development oriented events.



TVR 'Ramu' Pillay.

Taking the above challenge forward needed vision and dedication. It is in this regard that the vision of one man was crucial; Dr. T.V. Ramu Pillay took upon himself to uplift aquaculture and convince the governments, donors and development agencies the only avenue available to the world for meeting the increasing demand for seafood was through aquaculture. Consequently, a major aquaculture development project under the UNDP - FAO was born, and a milestone of this was the convening of a global conference, June 1976, in Kyoto, Japan, when the key strategies to be adopted were agreed upon in the Kyoto Declaration. These entailed the following elements:

- Raising the profile of aquaculture in government development plans and private sector investment priorities.
- Facilitating the transformation of the art of aquaculture to a science based sector
- Develop and generate the human capacity needed to forge ahead with the new innovations and practices
- Create mechanisms for knowledge exchange and adaptation within and between regions through appropriate networks.
- Create the appropriate political climate and the associated policy developments to back-up and facilitate the developments
- Coordination and integration of research

The results of the above initiatives are obvious when one looks at the aquaculture production alone; in 1976 it was only about 1 million tonnes, and the following two decades

it moved from 9.186 million tonnes (1986) to 26.593 million tonnes (1996). The Food and Agriculture Organization (FAO) of the United Nations Organization (UNO) began to carry forward the impetus on sustainable aquaculture development as a means of meeting the increasing demand for food fish whilst contributing to food security and livelihoods further. Correspondingly, major institutional changes were initiated, and that was the birth of networks such as NACA, that commenced as a project component and later transformed into an inter-governmental organisation with major lead centres to assist in this effort; governments began to embrace aquaculture as a development strategy with particular emphasis in association with rural development, human capital began to increase, and the science of aquaculture began to gradually mature. The importance and the recognition of aquaculture as a food production sector continued when member governments of the Food and Agriculture Organization (FAO) saw the need to set-up a Sub Committee on Aquaculture under the Committee on Fisheries, which was fulfilled in 2001.

The new millennium called for stock taking of the situation, especially in view of the overwhelming acceptance of the Millennium Development Goals, and in a dynamic world where sustainable development, environmental integrity and biodiversity became pivotal elements in all forms of human endeavour and development. Aquaculture in the Third Millennium, the global conference held in Bangkok in February 2000, was the 'stock taker', evaluator and the determiner for the way forward for the new decade. The keynote address on the occasion stated, "The two landmark events in the recent history of aquaculture are the holding of the FAO Technical Conference on Aquaculture, Kyoto, Japan in 1976, and the Conference on Aquaculture in the Third Millennium, in Bangkok, Thailand, in February 2000".

Where are we now? Within the first eight years of the decade food fish production from aquaculture increased from 32.416 to 52.546 million tonnes, with corresponding monetary values being 47.597 and 94.448 billion United States dollars- a notable improvement by any strength of imagination, and particularly for a primary production sector. Needless to say that the production and development surge over the last few decades have been spearheaded by PR China, where aquaculture is thought to have originated 2500 years or so back, and which continues to lead the sector globally. The developments since the 1970s have not only been confined to production levels and the revenue thereof. The developments have embraced many countries and regions resulting in aquaculture contributing more to the gross domestic product in many places such as in Chile, India, Thailand, Vietnam, than from the traditional capture fisheries sector. The developments have taken place in countries and regions that did not have a tradition of farming the waters, very different to farming on land, new species and groups have emerged, thereby impacting on the diversity of food types on our table. Most of all it has continued to provide employment and food security for millions, mostly in rural areas and for impoverished communities. The developments in the sector have had their critiques; and certainly have not always been smooth and unhindered either. This conference has now become the major global mechanism for shared learning and exchange for most stakeholders involved in this vigorous and rapidly evolving sector, and to evaluate how we should move forward in the decade or so.

Where are we going? It is time now to look at what is ahead in the current decade, and no better way to do so other than meeting together and arriving at consensus, and hence this gathering in September 22-25th in Phuket, Thailand. This gathering will address a wide range of issues of the sector, a matured and almost a fully fledged entity which will encounter a different set of global aspirations, and how best it could do so in the coming decade; a decade very different to those of the past. It is not production per se that is important and crucial to further forging aquaculture; how aquaculture production will meet the increasingly stringent food quality and food safety requirements; how the sector would adjust to changing market demands and aspirations; how the sector would effectively disseminate the knowledge and know how to others who need it; how the sector could become increasingly socially responsible; how the sector would continue its growth momentum without overly perturbing the environment; how the sector would use and share the common primary resources in an equitable manner; how the sector can make the optimum use of the differing regional strengths in a new invigorated inter regional approach; how the sector would respond to global impacts from climate change, and most of all how it can continue to contribute to food security and poverty alleviation and to the Millennium Development Goals.

Our hope is that the next gathering will be held in the African continent, when this continent having taken a leaf out of the “aquaculture book” of the Asia-Pacific would have made major strides in aquaculture development, contributing to rural income and food security.

NACA welcomes you to Phuket, Thailand, one of the most beautiful coastal towns in the world, and we look forward to your fruitful and effective participation at this important event.



From the 2000 conference in Bangkok, left to right: Mr Mahinda Rajapaksa, Minister of Fisheries and Aquatic Resources (now President of Sri Lanka), Mr Pongpol Adireksan, Minister of Agriculture and Cooperatives, Thailand, and Mr Hassanai Kongkeo, Coordinator of NACA (now Technical Assistant to the Director General).

Useful Information for Participants

Thailand is easily the most popular tourist destination in South-East Asia, and for good reasons: it is exotic, yet safe and largely hassle-free. Phuket, located approximately 90 minutes by plane from Bangkok, is Thailand's largest island, often dubbed the Pearl of the Andaman. Phuket retains its quintessential Thainess, with a culture and history all its own and a carefree people famed for their smiles and their fun-seeking "sanuk" lifestyle. Thai people predominantly follow Buddhist cultural traditions.

Phuket, Karon Beach

Karon Beach is 45 minutes away from Phuket International Airport only 10 minutes away from Patong, the centre of Phuket's nightlife. There are two 18 hole golf courses within 30 minutes drive. Karon is in the centre of it all with one of the longest stretches of beach in Phuket, famous for its squeaky white sand. Despite its size and full range of activities and facilities, Karon Beach is much less hectic than the other beaches. It has a promenade which runs by the many shops, seafood restaurants, and bars.

Basic Facts

Climate:

- Dry season (December-March) 24° C- 32° C
- Green season (June-October) 20° C-33° C
- Transitional periods (April-May and October-November) 26° C-36° C

Time: GMT +7 (No daylight-saving time)

Electricity: 220 Volts (50 cycles) Flat/Round plugs (Types: A/B/C)

Bank hours: 8:30 am to 3:30 pm (Monday-Friday)

Visas: 30 days on arrival for most countries

Health: No special vaccination requirements

Currency: Thai Baht

Getting about

Taxis are cheap and readily available around hotels, shopping centres and tourist attractions. You may insist on switching the meter on when you start your journey with a taxi to avoid any fee dispute. Not many Thai taxi drivers and or the public speak English and or other languages, or at least most are shy to do so. Whenever you leave your accommodation please ensure you carry a business card of your hotel and similarly if you wish to visit any place get the name and the address written in Thai to show the taxi driver for example.

Food

Phuket boasts of some excellent restaurants, and is particularly famous for its succulent sea food. Traditional Thai cuisine is hot to the palate of most but nevertheless it is worth a try. In Bangkok, as well as elsewhere in Thailand street food or hawker food is very common. Hawker food is delicious and very cheap.

Shopping

Most malls and departments stay open at least 21:00 and some even as late as 22:00. Some are very sophisticated, trendy and virtually able to accommodate every style and taste.

In addition, there are many night markets offering great after dark shopping opportunities too - and incredible bargains in the moonlight. These markets sell a variety of merchandise. In general, the prices are not fixed and you have to bargain and if you are not used to bargaining may be offer 50 % of the price the vendor quotes as a starting point.

Don'ts

There are some traditions you should strictly observe in Thai culture:

- You must be properly dressed to enter a temple premises, ie. your legs should be covered (trousers or long skirt), as should your shoulders; do not wear shorts or singlets.
- The King of Thailand and the Royal Family is sincerely revered by the populace and should not be a subject of discussion. Images, statues and portraits of the King and the Royal Family should be treated with respect.
- If you are invited to a Thai household, hopefully you will be able to experience this, you are expected to remove your shoes prior entry.

- Raising your voice, hand gestures and excessive display of emotions are considered impolite. If you encounter any difficulties the best solution is to remain calm and smile! You will find people very accommodating and helpful if you follow the local custom.

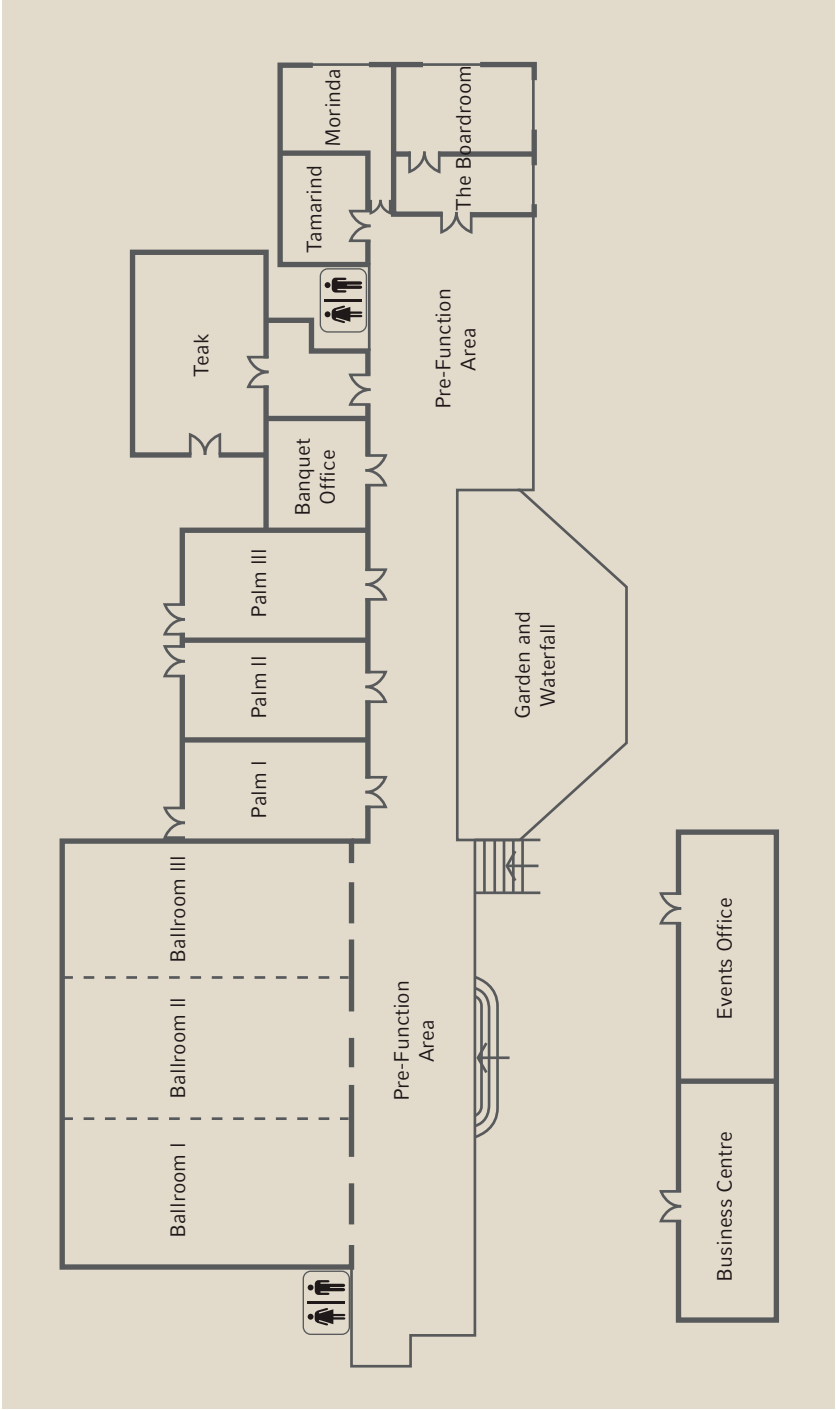
Leisure activities

Those who are visiting to the region for the first time you are advised to spend a few extra days and enjoy what Phuket and its surroundings offer. You cannot find a better place for snorkelling and scuba diving; island tours, each with its unique characters, on long tail boats are cheap, safe and enjoyable, are plenty; so is night life if it suits your taste - a lot of cabaret shows and discotheques; you name it Phuket has it all!!

Floor Plan and Location of Sessions (refer map opposite)

- **Plenary sessions:** Grand Ballrooms I to III
- **Thematic Sessions:** Grand Ballroom I & III
- **Side Events:** Grand Ballroom I & III
- **Registration:** Palm I
- **Poster Displays:** Palm II & III
- **Coffee/ Tea/ Lunches:** Pre-function Area
- **Secretarial Room:** Tamarind
- **Conference Dinner:** Grand Ballrooms I to III





Side Events

Improving sustainability of seafood production and trade: opportunities and challenges

Organisers: GTZ and FAO

Time and Venue: 1800 – 2000 - 22nd September – Ballroom 1

Global seafood trade is increasing and expanding. The responsibility of providing safe seafood produced in a sustainable and equitable manner to end consumer is a challenge to all involved. Stakeholders from developing and emerging economies are thus demanding practical instruments for fair, transparent and responsible farming practices. The side event will bring producers, processors, traders and consumers together to discuss opportunities and challenges for improving sustainability, responsibility, equity and viability of seafood production and trade. The Event will also provide a forum for discussing the challenges, experiences and lessons learnt with regards to developing standards for responsible aquaculture.

Aquaculture industry dialogue

Organisers: Thai Department of Fisheries, Norwegian Department of Fisheries and FAO

Time and Venue: 1800 – 2000 - 22nd September – Ballroom 2

Aquaculture now represents nearly 50 percent of the global aquatic food. The demand is growing and the sector is responding positively by continuous increase in production, globally. Also, the environmental performance of the aquaculture sector continues to improve as a result of a combination of appropriate legislation and governance, technological innovations, risk reductions and better management practices (BMPs). In many countries, sea-farming activities expanded as did promotion of multi-trophic aquaculture causing reduced environmental impact. While production is in the increase, all involved including farmers, processors, traders and consumers are facing challenges in bringing a safe and quality product to market at an affordable price, while maintaining aquaculture as a viable business. Discussions will focus on experiences and lessons learnt from around the world on addressing these challenges.

Introducing aquaculture research opportunities under the European Union's Seventh Framework Programme (FP7)

Organisers: EU Research Directorate-General DG-RTD and FAO

Time and Venue: 1815 – 2000 – 24th September – Ballroom 1

The objective of this side event is to inform the aquaculture research community and other stakeholders attending the Global Conference on Aquaculture 2010 about the EU initiatives for funding research in aquaculture, in particular the opportunities provided within FP7 for EU and non-EU participants. The event will endeavour to explain how the EU could contribute to support aquaculture research through communication on international research funded by the 7th Research Programme managed by DG RTD. The event will also provide a forum to set European research on aquaculture into a global context, and especially explore its links and complementarities with FAO activities.

Regional networking in aquaculture

Organisers: ANAF, NACA, NACEE, RAA and FAO

Time and Venue: 1815 – 2000 – 24th September – Ballroom 2

Networking and networks are critically important for the coordination of research, training and information exchange among the various stakeholders involved in aquaculture. This side event will bring together experts and experiences from existing and emerging regional networks in aquaculture including the Aquaculture Network for Africa (ANAF), Network of Aquaculture Centres in Asia-Pacific (NACA), the Network of Aquaculture Centres in Central and Eastern Europe (NACEE), and the Aquaculture Network for the Americas (Red de Acuicultura de las Americas - RAA), and will discuss and explore the relevance and future importance of regional as well as inter-regional collaboration for sustainable global aquaculture development.

Keynote Addresses

Plenary: Ball Room

Keynote Addresses

Professor Monkombu Sambasivan Swaminathan

Professor Swaminathan's main areas of research are cytogenetics, plant breeding, agriculture, biodiversity and eco-development. He was one of three from India included in TIME Magazine's 1999 list of the "20 most influential Asian people of the 20th century", the other two being Mahatma Gandhi and Rabindranath Tagore. He is a Fellow of the Royal Society of London, the U.S. National Academy of Sciences, the Russian Academy of Sciences, the Chinese Academy of Sciences, the Italian Academy of Sciences and the European Academy of Arts, Science and Humanities. He is a recipient of many distinguished international (e.g., Ramon Magsaysay Award for Leadership [1986], Albert Einstein World Science Award [1986], first World Food Prize [1987], UNESCO Gandhi Gold Medal, France [1999], Franklin D. Roosevelt Four Freedoms Medal, Netherlands [2000], Volvo and Tyler Prize for Environment, Shining World Leadership Award, Singapore [2007], Sahametrei Medal of the Royal Government of Cambodia [2007] and national (e.g. Lifetime Achievement Award of All Indian Management [2007], Lal Bahadur Shastri National Award [2007], Indira Gandhi Prize for Peace, Disarmament and Development [2000], Shanti Swarup Bhatnagar Prize [1961] awards and holds 58 honorary doctorate degrees from universities around the world. He will present a Keynote Address "Aquaculture and Sustainable Nutrition Security in a Warming Planet".



Mr Jiansan Jia

Mr Jiansan Jia has been working with the Food and Agriculture Organization of the United Nations (FAO) as Chief of the Aquaculture Service since 1998. Before joining FAO, he worked for the government of the People's Republic of China for more than 20 years holding several leading positions with provincial and central government authorities in both national and international agriculture and fisheries and aquaculture development (e.g. Director General of the China National Corporation for International Cooperation in Agriculture, Livestock and Fisheries; Director General of the International Cooperation, Ministry of Agriculture; Executive Vice-President of China National Fisheries Corporation, Deputy Director General of the Bureau of Fisheries; Vice Governor of Wujiang Country, Jiangsu Province). For the past 12 years, he has devoted himself to sustainable development of aquaculture at global and regional levels by leading the FAO Aquaculture Service based in Rome; he was one of the leading organisers of the Conference on Aquaculture in the 3rd Millennium held in Bangkok in 2000, and promoted the establishment and advancement of the FAO Committee on Fisheries Sub-Committee on Aquaculture. Mr Jia is currently the Co-Chair of the International Organising Committee of the conference. He will present a Keynote Address entitled "Global Aquaculture Development since 2000".



Keynote Address I

Aquaculture and Nutritional Security in a Warming Planet

M.S. SWAMINATHAN

Swaminathan, M.S., 2010. Keynote Address I. Aquaculture and Nutritional Security in a Warming Planet. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Fisheries and aquaculture contribute significantly to food and nutrition security. About 20 percent per capita intake of animal protein for more than 2.8 billion people is from fish and for over 400 million people fish meets 50% of the requirement for animal protein and minerals. Malnutrition is still the number one killer compared to other diseases and fish with its affordable protein and essential nutrients scores over other forms of animal protein. It is a rich source of micronutrients, minerals, essential fatty acids and proteins and is particularly important for the pregnant mother and in child health and development. An estimated 42 million people, majority of them from developing countries work full or part time as fishers and fish farmers. The potential for further improving livelihoods is huge, since it is the fastest growing food sector with 7% annual growth and with 37% by volume of world production traded internationally. For developing countries in relation to the combined earnings from the major agricultural commodities of rice, coffee, bananas, rubber, sugar and tea, the net earnings from fishery products are greater. Production from capture fisheries is not expected to increase much further, as most stocks have reached or exceeded their harvestable limits. On the other hand, aquaculture is growing more rapidly than all other animal food producing sectors, with an average global growth rate of 8.8 percent year since 1970. Of the total global aquaculture production of 68.3 million tonnes (valued at US \$ 106 billion), in 2008 from 340 plant and animal species, 93% was from developing countries and this underscores its importance in increasing the income of poor farmers. The importance of aquaculture in meeting the protein requirements from fish is evident from the fact that while kg per capita fish consumption rose from 14.9 in 1995 to 17.1 in 2008, the percentage contribution of aquaculture increased from 29 to 46% for the same period. If the current growth can be sustained, it is estimated to meet more than 50 percent of the total fish requirements by 2015. However the growth in aquaculture can be derailed by climate change unless measures to mitigate and adapt are put in place. Investments in aquaculture compared to other animal protein sources would bring better returns with regard to climate change in view of its considerable limited greenhouses gas and wastes produced per kg of meat.

Climate change is likely to increase the frequency and intensity of climate processes, such as El Niño-Southern Oscillation and there are indications that all surface waters of

oceans with some geographical variations are warming and increasing in salinity. Global sea level which has been rising due to climate change has accelerated after 1993. Many lakes especially those in Africa have shown moderate to strong warming since the 1960s. The likelihood of wetlands completely drying out more completely in dry seasons due changes in temperature and precipitation is increasing. The timing, duration and areas flooded are also expected to change. All these are expected to increase the frequency and intensity of extreme floods and droughts. These would increase the risk of livelihood loss and personal security. For example, the thriving catfish farming in Mekong which provides 150,000 livelihoods with a production of 1 million tonnes valued at 1 billion dollars per year would be jeopardised by saline intrusion due sea level rise. African countries which depend greatly on fish for protein and have the least capacity to adapt to climate change like Angola, Congo, Mauritania, Mali, Niger, Senegal and Sierra Leone are semi-arid with significant coastal or inland fisheries - it means higher vulnerability to future increases in temperature and linked changes in rainfall, hydrology and coastal currents. Island nations and others like Bangladesh would be greatly hit by the increase in frequency and intensity of storm and resulting flooding. Since all farmed fishes are poikilothermic, climate changes will significantly alter metabolism resulting in reduced, growth rate, total production, reproduction seasonality and increase vulnerability to diseases. Hence increase in temperature due to climate change will have a much stronger impact on aquaculture productivity and yields.

Aquaculture provides opportunities to adopt to climate change by integrating aquaculture and agriculture, which can help farmers cope with drought while increasing livelihood options and household nutrition. Water from aquaculture ponds can help sustain crops during periods of drought while at the same time the nutrient rich waters can increase productivity. Farmers can use saline areas no longer suitable for crops that are expected to increase due to sea level rise to cultivate fish. Taking advantage of the short generation time and high fecundity, it would be possible to selectively breed fishes to tolerate higher temperature, salinity and increased diseases that are likely to impact aquaculture due to climate change. Aquaculture depends heavily on capture fisheries for fish meal and in certain areas for seed and hence there is an urgent need to find plant protein based alternatives to fish meal and to domesticate species for which there is still a dependence on wild broodstocks. The adaptive response of different communities to Asian tsunamis needs to be evaluated to derive valuable lessons for future such extreme events that are likely to increase. To meet climate change there is a greater emphasis on renewable energy like offshore wind, wave and tidal energy and greater nuclear power capacity being proposed with coastal or inland water cooling and these can adversely affect coastal and inland aquaculture unless strategies to mitigate their effect are inbuilt. Finally it is necessary to increase the awareness on the potential to develop adaptive livelihoods, improve the governance and build institutions that can help people, integrate aquaculture in the overall climate change and rural development policies.

To adapt to sea level rise, we should promote agri-aqua farms. Seawater can be converted into potable water through mariculture cum agro-forestry involving mangroves *Salicornia*,

Atriplex, *Sesuvium* and *Casuarina*. Coastal aquaculture will then become an important component of sea water farming, thereby opening up new windows of opportunity for using sea water as an important ingredient of sustainable food and nutrition security system.

Keynote Address II

Global Aquaculture Development Since 2000: Progress Made in Implementing the Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000

JIA JIANSAN

Jia, J. 2010. Keynote Address II. Global aquaculture development since 2000: Progress made in implementing the Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

In 1976, FAO assisted in adopting the Kyoto Strategy for Aquaculture Development, which facilitated the transformation of aquaculture from a traditional to a science-based economic activity. It promoted technical cooperation among developing countries to expand national, regional and global aquaculture development. In 1995, promulgation of the FAO Code of Conduct for Responsible Fisheries enshrined the principles of sustainability and responsibility in the practice of fisheries and aquaculture. It sparked the development and increasing adoption of practical guidelines for responsible fishing, fish farming and trade in aquatic products. Subsequently, in 2000, NACA in collaboration with FAO and the Thai Department of Fisheries adopted the Bangkok Declaration and Strategy, which reconciled the development and management of global aquaculture into five key areas of sustainable aquaculture: the fundamental need for a responsible farmer to be justifiably rewarded; the social ideal of equitable sharing of costs and benefits; society's desire to benefit from aquaculture without being harmed by its practices and products; the pragmatic economic goal of providing livelihood and enough and affordable food to everyone; and the moral obligation to conserve the environment for the next generation.

It has been recognised that the principles and strategies advocated by the Kyoto Declaration on Aquaculture in 1976, the Code of Conduct for Responsible Fisheries in 1995, and the Bangkok Declaration and Strategy in 2000 have served well the process and goals of aquaculture development.

The aquaculture sector has further expanded, intensified and diversified during the past decade. The expansion of the sector is mainly due to research and development

breakthroughs, compliance to consumer demands and improvements in aquaculture policy and governance, in keeping with the guidance provided in the 2000 Bangkok Declaration and Strategy. Efforts to develop the sector's full potential and increase global seafood supplies have been aggressively pursued in recent years in order to create a regulatory regime supporting industry expansion and growth. The aquaculture sector has been developed in a more sustainable manner in keeping with the principles of ecosystem-based management and in accordance with the FAO Code of Conduct for Responsible Fisheries. However, these trends did not occur equally throughout the regions.

The aquaculture sector continued to enhance environmental performance through a combination of improved legislation and governance, technological innovations (water and discharge treatment) and better management practices. There is evidence of efforts towards application of ecosystem approach to aquaculture development in all regions. Many countries expanded their sea-farming activities and began to promote multi-trophic aquaculture with reduced environmental impact. Aquaculture networking improved and communication expanded. Technology strengthened, several new species emerged (tra catfish, tuna, cod, etc.) and some reached adequate production rates for an established market. The quantity and quality of seed and feed increased globally, taking into further consideration consumers' concerns as well as resource availability. Significant improvements in feed conversion and fishmeal reliance have been achieved in several species. In general, aquaculture health management improved. The use of veterinary drugs and antimicrobials came under increased scrutiny, and legal frameworks for controlling their use have been established in many countries, although effective enforcement of such laws is still constrained by a shortage of financial and human resources.

Although precise figures are lacking, aquaculture's contribution to poverty alleviation, food security, gender opportunities and employment and trade has increased over the past decade. This is reflected in the increase in volume and value of production and through the growing presence of aquaculture products in world markets, in particular as raw material to the processing sector and through the availability of aquaculture products to world consumers, including domestic markets. Various related issues such as ownership by the beneficiaries, people-centred approaches, growing species that feed low on the food chain, targeting all household members, use of farmer field schools-type methodologies and the use of technologies that are developed according to the local context with network approaches have all contributed to this.

Unlike many other sectors of the economy worldwide, aquaculture has been resilient to the global economic crisis. However, an extended crisis could damage the sector's growth, especially by limiting funds available for research and support to vulnerable groups such as small-scale farmers. Governments, in particular those in developing countries, need to have sound macroeconomic and public-sector management programmes in place in order to cope with the likely impacts. Governments also need to consider providing safety-net support to vulnerable groups, including those engaged in aquaculture activities, particularly as an adaptive response to the possible impacts of climate change. In addition, the

continued support of donor partners would be useful to sustain the economic and social achievements.

The two assessments of progress made by FAO in responsible aquaculture development and trade within the current decade, the first in 2005 and published as the State of World Aquaculture 2006, the second in 2009 and appearing as the Global Aquaculture Review 2010, have shown that: (a) the progress has been largely achieved by efforts made in line with the Bangkok Declaration and Strategy, (b) the Strategy remains relevant to the aquaculture development needs and aspirations of States, and (c) there are elements of the Strategy that require strengthening in order to enhance its effectiveness to achieve development goals and deal with persistent and emerging threats.

This Keynote elaborates the achievements made during the past decade, in keeping with the Bangkok Declaration and Strategy, which brought the aquaculture sector to the current level.

Regional and Global Reviews on Aquaculture

Plenary: Ball Room

Regional Review on Aquaculture Development in Sub-Saharan Africa

LEAD AUTHOR: BENEDICT SATIA

CO-AUTHORS: SLOANS CHIMATIRO, MATTHIAS HALWART

Satia, B., Chimatiro, S. and Halwart, M. 2010. Regional and Global Reviews on Aquaculture. Regional review of aquaculture development in Sub-Saharan Africa. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The contribution of Sub-Saharan Africa (SSA) to global aquaculture production remains insignificant but is increasing significantly. Between 1998 and 2007 there was a four-fold increase in production from 43,000 to slightly over 183,000 tonnes. The average yearly growth (APR) was 14.45 percent. This was due to the emergence and intensification of private sector led small and medium size enterprises and the expansion of large commercial ventures, stimulated in some cases by growing public support and the inflow of foreign capital and expertise. International awareness and interest in aquaculture spawned by the NEPAD Fish for All Summit in 2005 and implementation of the FAO Special Programme for Aquaculture Development in Africa (SPADA) also contributed to this development. The management practices of some of these undertakings are vertically integrated, environmentally responsible and socially acceptable. The operations adhere to standard sanitary operation processes and the entrepreneurs are adopting strategies to safeguard producers and consumers. Products from some of the enterprises are subject to labelling and certification.

The bulk of the production (93 percent) is from freshwater and is predominantly the culture of the indigenous and ubiquitous species of tilapias and African catfishes. In 2007 catfish contributed about 49 percent of the total production, and interest in the culture of the species for domestic markets, intra- and inter-regional trade and exports overseas is still growing in several countries. Mariculture contributes only 2 percent of total production quantity and 5 percent of total value but is an emerging and promising subsector. New production systems (for example, cages and tanks previously untried or unproven in the SSA) have been introduced, accompanied by the refinement of existing production systems. The tank system has application in a number of conditions, and it has a strong teaching aspect, as well as the capacity to serve multiple functions, including holding fish for sale or processing. Much of the production in Nigeria is based on the tank system. It is estimated that employment by the sector per country ranges from 18,000 to 30,000 jobs and in vertically large-scale farms, a high proportion of the employees are women. Integrated aquaculture, including rice-based aquaculture systems, is presently practiced in only a few countries but has great potential at the rural small-scale farmer level to contribute towards sustainable livelihoods by strengthening the ability of farmers to respond to threats in

their environment, improve their resilience and reduce vulnerability to shocks, as well as increasing food security.

Several governments are recognising that important roles for the state include facilitating, coordinating and adopting reforms to improve business environment that is not directly linked to aquaculture but has spill-over impacts on the sector. Some countries are divesting expensive infrastructure and undeliverable services; others have adopted aquaculture-specific policies and developed framework strategies providing a vision and roadmap to guide development. A few governments have provided soft credit lines in agricultural development and commercial banks, but access to affordable credit, seed and feed of sufficient quantity and quality, and land ownership or secure access to common property resources are major constraints to the expansion and/or intensification of production. The characterisation of species, selective breeding and the production of low-cost diets are the focus of research in a few centres. In the target countries under SPADA, on-farm participation in research using model farms and private enterprises is resulting in rapid diffusion of technologies through farmer-to-farmer pathways. Generally, extension services are weak and inadequately resourced. There is an urgent need to improve the individual services and also strengthen the links between research and development.

There is increased private-sector involvement in the production and delivery of inputs (seed and feeds) and the manufacture and supply of aquaculture equipment in some countries. At the same time, producer associations of one form or another are present in several countries at both the national and local levels and are playing a catalytic role in the sector, in terms of information flow, exchange of experience, and agenda and priority setting. The establishment of operational clusters of farmers is contributing to efficient delivery of support services, ensuring economies of scale, reducing transaction costs and improving competitiveness. In other instances, clustering of farmers but especially of farms has been a deliberate outcome of zoning areas for aquaculture based on the biophysical and socio-economic parameters of the given site.

The emergence of a fledging marketing component in the industry of some countries is contributing to improving the value chain of aquaculture. However, poor infrastructure and insufficient facilitation are two major constraints to the distribution of aquaculture products both within individual countries and for inter-regional trade. To meet consumers' demand for "ready-to-prepare" products, artisanal fish dressing industries are emerging at farm gates and markets. Value is also added to the products through freezing, drying and smoking, including the preparation of cool-smoked catfish fillets for export to Europe.

The top aquaculture producers in SSA include Nigeria, Uganda, Madagascar, South Africa and Zambia. There are several reasons why aquaculture has had spectacular growth in these and a few other countries during the past decade. They include the adoption of good governance, emphasis on capacity building to create the critical mass in strategic and targeted subject matter, emphasis on research and outreach, and the provision of credit. However the greatest catalyst is the promotion of private sector-led aquaculture

development, which has been manifested in these lead countries by investment in sound management, establishment of efficient commercial fish hatcheries, judicious choice of limited species, the development and use of aqua-feeds and new production systems, and the emergence of strong and dynamic producer associations and service providers.

As the sector develops and activities intensify, aquaculture will face several challenges such as: a growing demand for access to capital; the need for sufficient quantities and quality of seed and feeds; the severe competition with other resource (land/water/feed) users, and the need to strengthen the basis for aquaculture management, including the overall governance of the sector. However, with the stagnation of both marine and inland capture fisheries production, expanding markets and services, growing urbanisation, increased opportunities for private-sector development etc., the possibilities for increased growth are enormous, and there are indications that the APR of 14 percent witnessed during the past decade could be maintained in the medium term.

Aquaculture Development in the Asia-Pacific Region

LEAD AUTHOR: SENA S. DE SILVA

FAO FOCAL POINT: MOHAMMAD HASAN

De Silva, S.S., 2010. Regional and Global Reviews on Aquaculture. Aquaculture development in the Asia-Pacific region. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The Asia-Pacific region continues to lead in aquaculture production. Aquaculture production in the region was 11.94, 31.08 and 59.57 million tonnes in 1987, 1997 and 2007, and accounted for 85.5, 90.7 and 91.4 percent of the global production, respectively. The dominance of the region in the global aquaculture scene is also exemplified by the Asia-Pacific being the leading producer (in volume and value) of the major cultured commodities viz. finfish, molluscs, shrimp and seaweed, and nine out of ten of the current leading aquaculture-producing countries being from the region. Among the countries in the region, China has continued to maintain its dominance in aquaculture production.

Aquaculture practices in the Asia-Pacific region are very diverse and are conducted in fresh, brackish and marine waters, with overall freshwater finfish production being the most dominant. Also, aquaculture practices in the region are mostly small-scale, farmer- owned/ leased, operated and managed practices, often concentrated in areas that are conducive to aquaculture. In the last decade, the region has witnessed major developments and successes such as that of: (1) the change in shrimp culture practices from the indigenous black tiger shrimp (*Penaeus monodon*) to the exotic whiteleg shrimp (*Litopenaeus*

vannamei), indicative of the resilience and adaptability of small-scale farmers to unforeseen circumstances; (2) striped catfish (*tra*) farming in the Mekong Delta, Viet Nam, possibly the most explosive growth in an aquaculture commodity, within a restricted geographical area; (3) establishment of a significant export trade for a relatively low-value cultured commodity (Indian major carp (*Labeo rohita*), commonly known as “rohu”) in Myanmar; (4) the development of marine cage culture of relatively high-value finfish species in China and other Asian countries, with a gradual decrease of dependence on wild-caught seed stocks, among others. The region is also experiencing the increasing development and adoption of better management practices (BMPs) for major cultured commodities and farming systems. This combined with the organisation of farmers into clusters would add further synergies bringing about improvements in management, profitability and sustainability of small-scale farming and will facilitate these farming communities to meet the modern market demands on food quality and safety, and challenges collectively and effectively.

It is noted that the great bulk of aquaculture production in the region is of relatively low-value species, often commanding a farm-gate price of less than 2.0 US\$/kg and overall, the farm-gate price of most cultured commodities has remained relatively static over the last ten years or so, often placing small-scale farmers at the brink of economic viability. The need for taking measures to improve this trend in the coming era will be crucial to both the economic viability and sustainability of the sector at large in the region.

The review discusses the potential growth areas in aquaculture in the region, which include intensification of existing practices; more judicious and expansive secondary use of lentic waters, foremost through the development of cage culture; effective use of non-perennial waters (estimated at 66.72 million ha) for culture-based fisheries development through community management; and enhancing and improving upon the age-old rice-fish culture practices to meet modern market demands. The potential constraints confronting the growth of the sector and the possible strategies that would facilitate the expected growth from aquaculture and thereby continue to contribute to meeting the increasing food fish demands to food security and to poverty alleviation in the region are discussed.

Apart from those strategies that would bring about a direct impact on production increases, there is also a need to improve public perceptions on aquaculture through better communication of successes and their impacts on nutrition, food security, and social well-being; the contribution of aquaculture to biodiversity conservation and the increasing emphasis by the aquaculture community on attempting to cause minimal perturbation of the environment, to the extent that any form of food production system could achieve. These attributes will lead to better policy development and governance of the sector, thereby further facilitating the sector's growth in the region. The region will be more cautious of the use of alien species in aquaculture development, particularly in respect to new introductions, and will also ensure that measures are taken to bring about induction of scientific know-how on maintaining genetic diversity in broodstock management of newly emerging species. A number of selective breeding programmes have started for major commodities such as tiger shrimp, rohu, tilapia and common carp, and there is a need to evaluate the impacts

of genetically improved strains on the overall production figures. Also, this highlights the need for development of mechanisms for access and benefit sharing (i.e. dissemination of improved strains) of the genetic resources. Increasing communication and use of modern technologies to do so, among small-scale farmers in the region will be crucial in disseminating knowledge, keeping farmers informed of the fast-changing global market place and leading to adoption of technological innovations.

The region will have to be alert and continue to develop mitigating measures for the potential climatic change impacts on the sector. In this regard, the most vulnerable in the region would be those systems that are located in deltaic areas, such as the Mekong, Ganges-Brahmaputra, Red River etc., which also happen to be hubs of aquaculture activity, and means of millions of livelihoods.

Aquaculture in the Asia-Pacific region is on a firm footing and will continue to contribute increasingly to global foodfish supplies, income generation, food security and poverty alleviation, in spite of the major global challenges and constraints faced by such developments. It will continue to forge ahead and be the global leader and will do so through the dedication and resilience of small-scale farmers who constitute the backbone of the sector, as in the case of all primary production sectors in the region, but with ever increasing awareness of achieving sustainability with minimal environmental perturbation and impacts on biodiversity.

Regional Review on Aquaculture Development in Europe

LEAD AUTHOR: LASZLO VARADI

CO-AUTHORS: EMESE BÉKEFI, GERGŐ GYALOG, YVES HARACHE, ALISTAIR LANE, PÉTER LENGYEL

FAO FOCAL POINT: UWE BARG

Varadi, L., Békefi, E., Gyalog, G., Harache, Y., Lane, A., Lengyel, P. 2010. Regional and Global Reviews on Aquaculture. Regional review on aquaculture development in Europe. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Between 1990 and 2007, the production volume of European aquaculture increased by 54.3 percent, from 1,622,000 tonnes to 2,504,000 tonnes, while the production value doubled, from US\$ 4,076 million to US\$ 8,812 million. The increase was mainly attributable to the growth of marine finfish aquaculture, while freshwater aquaculture production declined. Between 2002 and 2007, the overall production volume slowed down, showing an increase of +17.7 percent. Europe produces only about 4 percent of the global aquaculture production, but European technologies and knowledge contribute significantly to the global aquaculture development. Farming systems, technologies and species are very diverse

in Europe. Significant research and development has focused on improving the efficiency of production systems and the quality of the produced fish, while mitigating environmental impact. Innovations in selective breeding and life cycle manipulation have contributed to the improvement of efficiency and quality of juvenile production. For emerging species, the most pressing bottleneck is the supply of juveniles, but research has led to significant achievements in the culture of cod, meagre and others and more recently, in the captive breeding of bluefin tuna.

In Europe, aquaculture generally has a marginal contribution to national economies and employment. The total employment in aquaculture is currently around 150,000 full time equivalents, which is small, but may contribute locally to significant economic activities and employment. Extensive and semi-intensive systems employ more people per unit production than modern intensive systems.

The region accounts for 14.5 percent of the world consumption of fish and fishery products. However, the European Union (EU) market is not a homogeneous one. Southern European countries show the highest per capita consumption; countries in Northern Europe show average levels (around 20 kg/year per capita) and those in Central and Eastern Europe show levels well below average.

The European market is increasingly dependent upon imports. Some 1.65 million tonnes (live weight equivalent) of farmed seafood products were imported into Europe in 2008. Almost half of this is salmon, although imports of *Pangasius catfish* and tilapia from Southeast Asia have demonstrated remarkable growth in recent years. Exports from the EU totalled only 100 000 tonnes in 2008 and included mainly high-value processed products. Harvest and post-harvest services are significant components of the aquaculture industry in Europe. The annual value of processed fishery products produced by the sector is about 24 billion USD per year, almost twice the value of landings and aquaculture production combined. Production has grown in recent years, but employment has been contracting due to advances in processing technology, industry consolidation and especially through the trend to outsource certain processing operations to third countries with lower labour costs.

The first European strategy for sustainable aquaculture development was developed in 2002. In 2007, the European Commission reviewed the status and impact of that strategy and launched an extensive consultation with stakeholders. This led to a new communication "Building a sustainable future for aquaculture. A new impetus for the Strategy for the Sustainable Development of European Aquaculture" (COM (2009) 162 final) aiming to address the obstacles to growth faced by the industry. The new strategy looks to make EU aquaculture more competitive, ensure sustainable growth and improve the sector's image and governance.

Community legislation covers all stages of the production, processing, distribution and placing on the market of food intended for human consumption. Special attention is devoted to labelling of fishery and aquaculture products. The markets have responded to

the interest of European consumers in issues like traceability, fair trade, animal welfare and environmental impacts with voluntary certification and labelling schemes operated on a transnational basis, but often with different standards. Organic aquaculture standards are currently limited to relatively few countries and species, although a new European Commission Regulation is now setting out a common standard for various types of fish and shellfish aquaculture. There is no single European ecolabel as yet for aquaculture products, but some producers have adopted animal welfare standards or farm management and geographic accreditation. Certification also extends through the value-chain, with retailers developing their own “better farm management” standards.

While Europe as a whole enjoys a rich aquaculture research environment, it is very diversified and fragmented between public and private institutes, universities and other higher education establishments and private companies. There is a considerable overlap in research and dissemination and especially, the application of the research outputs remains a challenge. In 2000 the EU created the European Research Area (ERA), creating a unified area across Europe to address these issues. European organisations, such as EFARO (European Fisheries and Aquaculture Research Organisation) and NACEE (Network of Aquaculture Centres in Central and Eastern Europe) have considerably increased their regional cooperation. Inter-regional cooperation is generally less advanced, although new initiatives, such as the ASEM aquaculture platform, address cooperation between Europe and Asia. Aquaculture (and fisheries) networks continue to be created or developed or their activities broadened, e.g. AQUA-TNET. An important recent development has been the establishment of the European Aquaculture Technology and Innovation Platform (EATIP) for a better dialogue between the aquaculture industry, the research community, consumers and policy-makers.

The protection of consumers, the responsible use of resources and the protection of the environment will remain key challenges in the development of aquaculture technology and systems. The wider exploitation of inland and coastal waters for aquaculture might often be increasingly constrained by a growing competition from other users as well as by regulatory restrictions, unless new aquaculture technologies are adopted. At the EU level, the main regulatory and legal constraints appear to be a lack of a common approach to licensing, concerns about the Water Framework Directive’s potential to constrain the development of aquaculture, interpretation of legislation concerning the predation of aquaculture stocks by protected species and the application of environmental impact assessment at the local level. One way forward would be the bringing together of all regulatory aspects into one aquaculture “framework”, but this has yet to be defined.

Regional Review on Aquaculture Development in Latin America and the Caribbean

LEAD AUTHOR: CARLOS WURMANN

FAO FOCAL POINTS: DORIS SOTO, ALEJANDRO FLORES

Wurmann, G.C. 2010. Regional and Global Reviews on Aquaculture. Regional review on aquaculture development in Latin America and the Caribbean. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/ Thailand Department of Fisheries. Phuket, Thailand.

The Latin America and the Caribbean Region (LAC Region) is a region on the move, not only in socio-economic and political terms, but also in what refers to aquaculture. With a population of over 561 million inhabitants (2005), it accounts for 8.7 percent of the world's total population and is responsible for about 8.5 percent of the global Gross Domestic Product (2007), showing as well the highest life expectancy at birth among developing regions.

A traditional fishing area excelling in the production of wild species (17.2 million tonnes per year in 2005–2007), particularly small pelagics off Peru and Chile, the region accounts for 12–13 percent of total world landings (wild and farmed) of fish products. Aquaculture, in turn, is less relevant, but has grown very rapidly, rising from about 8,400 tonnes per year in 1975–1977 to 1.7 million tonnes per year in 2005–2007, valued at 7,033 million US\$ in 2006 (19.3 percent growth per year, compound), more than doubling the world growth rate of 8.3 percent during this same 30 year period. In so doing, and taking into account the more modest growth rates of wild fish production, local aquaculture's contribution to total regional fishery output has risen from a mere 0.1 percent in 1975–1977 to 8.8 percent in 2005–2007.

However successful this growth process, LAC aquaculture is mainly based on four species (salmon/trout, shrimp, tilapia and mussels). In fact, salmon/trout and shrimp alone account for about 80 percent of the value and 66 percent of the volume farmed along the region in 2005–2007. Similarly, of 32 countries and territories registering aquaculture production in 2005–2007, South America is responsible for 81.8 percent of the volume and 86 percent of the value farmed. Here, only three countries – Chile, Brazil and Ecuador – account for 74.5 percent of the volume and 77.9 percent of the value farmed in this last triennium. Adding Mexico and Colombia, these five nations explain 87.1 percent of volume and 89 percent of the value farmed in 2005–2007.

Even with limited aquaculture production, the LAC Region is already outstanding in salmon/ trout production and exports, so that Chile is the most important foreign supplier of the United States and Japanese markets for those products, while Ecuador, Honduras and

Costa Rica are the main suppliers of fresh tilapia fillets to the important and growing US market.

This very high degree of concentration of LAC aquaculture production is also accompanied by a diversification process that involves the farming of up to 86 different species during some periods. Concurrently, though, most of them are produced in very low quantities, to the point that 59 percent of all species farmed regionally show annual productions below 1,000 tonnes in 2005–2007, and 78.2 percent of them are below 10,000 tonnes per year in the same period. This means that 48.1 percent of all species farmed in the LAC Region show a mean annual ex-farm value of less than US\$ 1 million, and 73.4 percent of them have a value of less than US\$ 10 million (2005–2007), figures that speak for themselves of the still-limited contribution of the current diversification efforts.

Irrespectively of the limited achievements in local aquaculture, this paper refers to the region's potential for future development, on account of its natural environmental conditions, the availability of space, water resources, etc., factors to which apt human resources and infrastructure can be added. Even though good and fairly open market opportunities are discussed and exposed up to the year 2030, the text also discusses a number of limitations and restrictions to making these developments possible. Among them, the most relevant obstacles may be the lack of proper governance, research and development and managerial aspects.

The paper also calls attention to prevailing inequities that prevent and/or discourage access to aquaculture production by small-scale farmers. Current norms and market conditions also tend to discourage their active participation in this industry, implying that there is an inexcusable need for governmental help in providing technology and technical assistance to these producers, but above all, covering a number of other issues, including management, market and marketing, financial aspects, logistic, etc. that commonly become the soft spots that have made past support efforts fail for most part.

Even aquaculture opportunities and development potential in this region are promising, it is essential that local governments have the will and eventually the financial and human resources to embark on a development adventure to further promote the sector. Even if this activity looks attractive and open-ended to many in the region, it is still somewhat obscured by relatively poor visibility, low priority, and not necessarily the best of public images.

Regional Review on Aquaculture Development in the Near East and North Africa

LEAD AUTHOR: ISSAM KROUMA

CO-AUTHORS: FEISAL BUKHARI, ABDEL RAHMAN EL-GAMAL, IZZAT FEIDI, ALESSANDRO LOVATELLI, SHERIF SADEK

Krouma, I., Bukhari, F., El-Gamal, A.R., Feidi, I., Lovatelli, A., Sadek, S. 2010. Regional and Global Reviews on Aquaculture. Regional review on aquaculture development in the Near East and North Africa. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Fish farming in the Near East and North Africa Region has been practiced for centuries; however, modern aquaculture started in the late 1920s and expanded considerably over the last three decades. Despite the modest production output from the region, aquaculture increased fourfold in the last decade from almost 198,000 tonnes valued at US\$ 496 million in 1998 to just under 850,000 tonnes valued at US\$ 1,927 million in 2007. The main driving forces responsible for the expansion of the sector have included an increased public health awareness and interest in fish products, the passing of enabling policies driven by the need for consolidating domestic fish supply, compensating for declining capture fishery landings, strengthening the livelihood of rural communities and supporting food security programmes. Governments in the region have played an important role in improving the business environment through financing applied research projects and motivating private enterprises through incentive legislation, securing production inputs, creating soft credit lines and dealing with leasing aquaculture rights in open water bodies.

The region covers an area of about 11.3 million km² with an estimated population of 355 million and a density of 31.5 inhabitants/km². Illiteracy and unemployment are comparatively high. Aquaculture has predominantly employed men; however, recent income-generating programmes have focused on supporting opportunities for rural females and their families. Topographically the region is characterised by vast arid areas that occupy over 75 percent of the total land mass, while arable and permanent crops-land make up for less than 6 percent. None of the countries are land-locked, and the combined coastline stretches for 20,100 km. Water in the region is a scarce and valuable resource restricted to two major river systems: the Nile in the African sub-region and the Euphrates-Tigris system in the Asian sub-region.

The top five producers in the region, i.e. Egypt, the Islamic Republic of Iran, the Kingdom of Saudi Arabia, Iraq and the Syrian Arab Republic contributed 99 percent of the total regional production in 2007. This production was dominated by finfish (98 percent), with Nile tilapia at the top (32 percent), followed by mullets (30 percent), cyprinids (24 percent), rainbow

trout (7 percent) and other species (7 percent). Over 68 percent of the production came from brackishwater earth ponds, while yields from freshwater (mainly ponds, rice fields, cages and raceways) and marine (mainly cages) farming practices contributed between 30 and 2 percent, respectively. In terms of species cultured, the majority were finfish (33 species), followed by crustaceans and molluscan bivalves with only three and two species, respectively.

Aquaculture research programmes in the region have focused mainly on production techniques for ubiquitous and valuable species, on productivity enhancement, on nutrition and production of cost-effective feeds and to a lesser extent, on genetic improvements. However, despite research activities being significant in some countries, the region as a whole lags behind in terms of applied research in support of the industry, with often inadequate and ineffective training and extension services to transfer farming know-how and management practices. Regional and international organisations have, however, contributed to the capacity building programmes in the region. These shortcomings have been recognised, and innovative research plans across the region are expected to focus on the needs of the sector, engage private farming operations and address aquaculture diversification using indigenous and commercial species.

Commercial aquaculture operations have increasingly focused on environmentally responsible practices to warrant the proper use and conservation of existing natural resources. In this regard, governments across the region have been enacting regulations and guidelines to ensure a sustainable growth of the sector. With the exception of specialised marine fish feeds, fish feeds are generally manufactured locally, often with some imported components, but always void of antibiotics. Except for experimental farming trials, fish and shrimp seeds are locally produced, mainly from small- and medium-sized hatcheries, or captured from the wild.

Across the region, policies governing the use of freshwater are being revisited to some extent in order to ensure the optimal and rational management of this scarce strategic resource. There is a general tendency to promote, particularly with reference to the use of freshwater, water-saving aquaculture practices (e.g. recirculation systems), as well as strengthening integrated aquaculture systems, to ensure the rational use of natural resources and secure further employment and social wellbeing of rural labour. Strategic support is also being given to the development of mariculture (particularly finfish cage and shrimp farming) through the introduction of technologies, policies and regulations that encourage investment, particularly with regards to licensing and sea leases.

Promotion of an economically sustainable aquaculture industry in the region has been challenging, particularly with regard to freshwater fish farming. Yet the region has a great potential to expand its industry through the employment of suitable and environmentally friendly technologies. Furthermore, mariculture in the region is still at an infant stage; however, in recent years a growing number of commercial shrimp farms and fish cage-farming operations using floating and submerged cages have been established and

encouraging new investments. Policy and regulation reforms that have supported aquaculture development over the past decade well reflect the recommendations and strategy of the Bangkok Declaration adopted in 2000 following the Conference on Aquaculture Development in the Third Millennium (20–25 February 2000, Bangkok, Thailand). It appears that the sector will continue to expand, particularly as new technologies are being introduced and institutional capacities are being strengthened.

Regional Review on Aquaculture Development in North America

LEAD AUTHOR: PAUL OLIN

CO-AUTHORS: RASHED NABI, JAMES SMITH

FAO FOCAL POINTS: JOSÉ AGUILAR-MANJARREZ, DEVIN BARTLEY

Olin, P., Nabi, R., J. 2010. Regional and Global Reviews on Aquaculture. Regional review of aquaculture development in North America. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

This review covers the status and trends in aquaculture development in North America including the nations of Canada and the United States of America. The review is organised by thematic areas including the social and economic background of the region; general characteristics of the sector; resources, services and technologies; aquaculture and environment; markets and trade; contribution of aquaculture to food security, social and economic development; external pressures on the sector; the role of shared information, research, training, extension and networking; governance and management of the sector; and the implementation of the Bangkok Declaration.

FAO has projected the need for an additional 1.3 to 1.4 million tonnes of seafood annually to supply projected increases in global consumption. In North America, per capita consumption is now around 8 kg. With the population expected to add 52 million people by 2025, approximately 416,000 tonnes of additional seafood will be required to meet demand. Canada and the United States are industrialised nations with the natural resources and investment capital to significantly expand aquaculture production to meet this demand. The Canadian and United States of America's gross domestic products (GDP) are US\$ 1.3 and US\$ 13.2 trillion, respectively. While the economies of Canada and the United States derive their growth and GDP mainly from the service and manufacturing sectors, primary-sector industries such as agriculture (including aquaculture) are important, especially in a regional context.

General characteristics of the aquaculture sector in North America include finfish production, which is dominated by salmon and catfish, and shellfish production, primarily of oysters, mussels and clams. North American aquaculture production in 2007 was 695,050 tonnes valued at US\$ 1.7 billion, up from 536,169 tonnes in 1998 for an Annual Percentage Rate (APR) of 2.9 for the decade. American production of 526 281 tonnes eclipsed Canadian production of 168,769 tonnes, but product value of US\$ 912 million and US\$ 788 million, respectively, were more closely matched, reflecting the higher value of Canada's primary product of Atlantic salmon relative to channel catfish, the primary species produced in the United States. Culture methods include marine net-pens for salmon, freshwater ponds for channel catfish, and a variety of on and off-bottom techniques for shellfish.

Canada is the second largest country in the world comprising nearly 10 million km², while the United States is slightly smaller at 9.6 million km². The American water surface area is 470,131 km² or about half of Canada's 891,163 km². The American coastline is 19,924 km long, while the Canadian coastline is much longer at 202,080 km. These natural resources provide an abundance of potentially suitable sites for supporting both marine and freshwater aquaculture. While resources are abundant, there are often conflicting demands, and marine spatial planning is increasingly seen as a tool to allocate access.

The North American service sector is well developed, with ready access to feeds, equipment, manufacturing, fingerlings, seedstock and veterinary services. Concerns over the use and future limitations of fishmeal and oil as feed ingredients have spawned alternative feed initiatives to identify suitable alternate feed ingredients. Health management and biosecurity are high priorities for producers and regulatory agencies in North America. Canada implements a National Aquatic Animal Health Program and the United States has developed a National Aquatic Animal Health plan that is under final review for adoption in 2010.

Canada and the United States have well established regulatory programmes and environmental values that demand sustainable aquaculture practices to protect natural resources. As a result, the industries have developed environmental policies and codes of practice that protect the environment in which they operate. Inherent in this process is a focus on ecosystem-based management and environmental approaches to aquaculture. Integrated multi-trophic aquaculture is being investigated as one technique to enhance environmental compatibility.

Markets and trade vary considerably between Canada and the United States. Nearly 90 percent of Canada's aquaculture products were exported in 2007 and 96 percent of sales were to American consumers. Total value of Canadian exports was US\$ 613 million in 2007. Most American production is consumed domestically and in 2008, Americans imported 83 percent of seafood consumed worth a record US\$ 14.2 billion. Trade and export of aquaculture products require a comprehensive and stringent food safety programme, and the Canadian and American seafood safety programmes are recognised as models throughout the world.

Direct and indirect employment in North American aquaculture was estimated at 52,129 jobs in 2007, up from 40,212 in 1998 for an APR gain of 2.9 percent. Aquaculture is a very small segment of North American agricultural production; however, on a regional basis it is extremely important to some communities in both Canada and the United States.

The North American aquaculture industry has adapted well to animal health challenges in the past. In the future, challenges related to climate change, global warming, sea level rise, severe storms and ocean acidification will require adaptive management and flexibility to sustain the industry. The need for scientific research remains critical to enhance the growth and diversity of North American aquaculture. Federal, state and provincial government research facilities are dedicated to research on new species development, selective breeding to improve performance and seed quality, enhanced grow out technologies, health management, and improved husbandry, nutrition and feeds.

Aquaculture is managed in North America by a combination of federal, provincial, state and local authorities, and over the last decade governments in both Canada and the United States have made concerted efforts to improve aquaculture governance. This must continue to improve regulation of the industry and balance the need to protect the environment, sustain fisheries and enable a competitive industry to flourish.

Canada and the United States have supported aquaculture over the last decade and both governments have created national aquaculture development plans in keeping with guidance provided in the 2000 Bangkok Declaration and Strategy.

Trends in Global Aquaculture Development

LEAD AUTHOR: IMTIAZ AHMAD

CO-AUTHOR: ROHANA SUBASINGHE

Ahmad, I. and Subasinghe, R. 2010. Regional and Global Reviews on Aquaculture. Trends in Global Aquaculture Development. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Global production of fish from aquaculture has grown substantially during the past decade, reaching 52.5 million tonnes in 2008 compared with 32.4 million tonnes in 2000. Aquaculture continues to be the fastest growing animal food producing sector and currently accounts for nearly half (45.6 percent) of the world's food fish. Although precise data are lacking on some aspects of the impact of aquaculture, it is apparent that aquaculture's contribution to poverty reduction, food security, employment, trade and gender opportunities increased over the past decade. With stagnating global capture fishery production and an increasing

population, aquaculture is perceived as having the greatest potential to produce more fish to meet the growing demand for safe and quality aquatic food.

Global aquaculture, however, has not grown evenly around the world. There are marked intra and inter-regional and country variations in a number of areas, such as production level, species composition, farming systems and producer profile. The Asia-Pacific region continues to significantly dominate the aquaculture sector globally, accounting for more than 90 percent of global production, with China alone contributing more than two-thirds of global production.

In case of species, few countries dominate production of major species, such as carps by China, shrimps and prawns by China, Thailand, Vietnam, Indonesia and India, and salmon by Norway and Chile. In terms of farming systems, while all three systems - extensive, semi-intensive and intensive - are practiced in most of the regions, intensive system is more prevalent in North America and in advanced aquaculture producing countries in Europe and Latin America. In the Asia-Pacific region, despite major technical developments in the aquaculture sector, small-scale commercial producers continue to remain the backbone of the sector for their significant contributions. Small-scale producers and small and medium entrepreneurs are also important players in the Africa region. Commercial and industrial scale producers dominate in Latin America, but there is strong potential for development of small-scale producers.

Over the past decade, a number of developments have contributed to the significant growth of the global aquaculture sector, namely: formulation and implementation of policies, strategies, plans and legislations; dissemination and use of applied research; and emergence of new domestic and international markets.

An increasing number of countries have formulated or are in the process of formulating fisheries policies, strategies, plans and legislations that facilitate growth and efficient management of the aquaculture sector. For example, in Africa, the spectacular development of aquaculture in some countries, such as Nigeria, Egypt, Uganda and Mozambique, has been due to government policies in favour of the private sector. There are also cases of many countries using aquaculture legislation to address competition for scarce land and water resources from other development activities through, for example, zoning.

Over the past decade, the Asia-Pacific region has contributed to two significant R&D programmes: the development of Genetic Improvement of Farmed Tilapia (GIFT), strain of Nile Tilapia, a landmark achievement in the history of genetic improvement of tropical finfish; and the closing of the life cycle of southern bluefin tuna, *Thunnus maccoyii*. R&D achievements in Europe have also contributed to improved efficiency of farming systems, leading to production of better quality of fish. Examples of new technologies include the development of underwater surveillance to manage feeding and biomass; and the development of integrated multi-trophic production systems. Further, to address the issue of sustainability of using fishmeal and fish oil in aquafeeds, global research efforts continue

to find affordable and high-quality plant and animal-based feed ingredients. The regional networks of aquaculture centres have also been playing a vital role in disseminating research findings.

In line with the increased growth of global aquaculture production, there has been an impressive development of trade in many aquaculture products. Two aquatic products from the Asia-Pacific region stand out: white-legged shrimp, *P. vannamei*; and the explosive growth of the tra catfish, *Pangiasodon hypophthalmus*, farmed in Vietnam. Further, there has been an increasing globalisation of the fisheries value chain, or outsourcing of certain processing operations to third countries with lower labour costs. Another parallel development is the integration of producing and processing activities, as in the case of salmon by large producers in Latin America. While the demand for aquaculture products continues to increase, there is growing recognition to address consumers' concerns for quality and safe products, and animal health and welfare. Thus issues such as food safety, traceability, certification and eco-labeling are becoming increasingly important and considered as high priority by many governments.

The global aquaculture sector's long-term goal to achieve economic, social and environmental sustainability primarily depends on continued commitments by governments to provide and support a good governance framework for the sector. It is encouraging that the experience of the past decade indicates that many governments remain committed to good governance. As the sector further expands, intensifies and diversifies, it should take into cognisance the environmental and social concerns, and make conscious efforts to address those in a transparent manner. In the process, the sector should also prepare itself to face the potential impacts of climate change and global economic crisis, and make special efforts to assist small-scale producers by organising them into associations and through promotion of better management practices, as has been successfully demonstrated in many countries. It is hoped that, as the new decade unfolds, a stronger and confident sector will stand ready to face and overcome the future challenges and move further along the sustainability path.

Plenary Lectures

Ballroom

Plenary Lecture I

Resources and Technologies for Future Aquaculture: A Needs Assessment for Sustainable Development

PATRICK SORGELOOS

Sorgeloos, P. 2010. Plenary Lecture I. Resources and technologies for future aquaculture: a needs assessment for sustainable development. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/ Thailand Department of Fisheries. Phuket, Thailand.

According to the latest FAO statistics, aquaculture is still the fastest growing food production sector in the world, i.e. in 2008 farmed seafood – fish and shellfish – represented about 53 million tonnes, up more than 20 million tonnes from a decade ago. Today farmed product represents about 50 percent of the seafood consumed by humans.

The continued stagnation in wild catches, coupled with a growing world population and increasing per capita consumption of fish puts a lot of pressure on aquaculture, i.e. FAO estimates that ten years from now an additional 28 million tonnes of aquatic food will be required on an annual basis just to maintain current levels of consumption.

Close to 80 percent of all farmed seaweed, fish and shellfish is produced in the Asia-Pacific region, the region with the longest tradition in aquaculture. In fact, artisanal farming practices developed empirically, and most of the production today is dominated by small-holder practices involving many millions of farmers. In sharp contrast with current developments in modern aquaculture in the West, Asian farming practices are mainly based on species low in the food chain and are often integrated in natural ecosystems, practicing maximal nutrient recycling in polyculture systems that take maximal benefit of all possible levels in the food web, e.g. co-farming of various species of fish, shellfish and plants occupying different niches in the ecosystem and benefiting from each other directly or indirectly for food, shelter, etc. Several forms of integrated farming of aquatic and terrestrial plants as well as animals are still popular practice in many Asian countries, e.g. rice-cum-fish culture, pig/duck/chicken-cum-fish farming.

By the late 1960s, modern “business” aquaculture had evolved, initially in Japan and later in Europe and the United States of America, when the reproductive biology and controlled larviculture of a few high-market-value species could be practiced and intensive monoculture on-growing practices were developed. This soon resulted in a number of success stories, with the intensive culture of temperate species occurring first (e.g. salmon, trout, catfish) and as of the 1980s, with species grown in tropical and subtropical conditions (e.g. seabass, seabream, penaeid shrimps, oysters, clams, seaweeds). This monoculture

practice has also been introduced in several Asian countries with *Pangasius*, tilapia, etc. Farm consolidation and vertical integration of production, often on a contract basis with small farmers, is in full progress in the West as well as the East.

Species selection was mostly based on business opportunities rather than their dietary needs, i.e. several aquaculture species are high in the food chain and as predators have high dietary needs for animal proteins. The fast expansion of aquaculture could not cope with the limited fishmeal and fish oil resources available from capture fisheries, and as a result, the sector is in high need of alternative protein sources. Furthermore, regional concentrations of monoculture practices resulted in significant environmental impacts, including water quality deterioration and pathogen and escapee impacts on local fauna, etc.

FAO is concerned that the momentum of growth could taper off if governments and development agencies don't adjust their policies to emerging challenges that threaten to thwart the sector's future growth. As major challenges, we mention the lack of investment capital for small producers in the developing world, shortages of land and freshwater or related resource conflicts with other sectors, rising energy costs, environmental impacts and questions of product safety. Too few species are domesticated – the result of this being that the benefits of working with selective breeds remain an illusion. Big disease losses continue to occur; the limited knowledge of life histories affects the ability to apply appropriate preventive measures, and there is a continued dependence on fishmeal and fish oil in feed formulations.

In view of these many challenges, considerably higher investment in basic research is urgently required to increase our knowledge of the biology of aquatic organisms and to develop more ecologically and economically sustainable farming practices with due consideration of socio-economic conditions.

The use of modern biotechnology “omics” tools should make it possible to let aquaculture evolve from an empirical science to a knowledge-based biotechnology with much more emphasis on fundamental research in order to unravel the underlying mechanisms in growth and product quality of aquatic species, their endocrinology, immune systems, behaviour, etc. Application of proven experience from other disciplines in agriculture and animal production offers unique opportunities for significant progress in seafood production in the decades to come.

More attention is also needed for the selection of species low in the food chain, especially those that can be farmed in extractive culture systems. Furthermore, species need to be better differentiated into products for bulk markets versus niche markets.

In view of future competition for freshwater resources, opportunities for integration of aquaculture with other food and/or bio-fuel production systems, aquatic as well as terrestrial, needs to be better explored and their sustainability impacts better documented. Off-shore industries that combine energy generation, food and feed production and blue biotech

innovations offer great potential for large-scale applications. In this regard, we need to better understand energy and nutrient flows in existing/traditional systems (e.g. the large-scale polyculture systems in coastal China) to document the bioremediation effect of seaweed and mollusc production in highly eutrophic areas and/or in combination with monoculture “business aquaculture” practices.

A concerted multidisciplinary effort of oceanographers/marine biologists, fisheries scientists and aquaculture practitioners should better explore possible integration of aquaculture practices with fisheries management and eventually improve socio-economics of the fisheries sector in various regions of the world.

Domestication efforts should receive higher attention in order to achieve independence from natural stocks and open ways for the development of more efficient stocks through selective breeding.

Today we still underestimate the critical role of microflora in the production biology of aquatic systems, e.g. in nutrient recycling, micronutrient generation, digestion and immune stimulation, etc. Proper R&D should generate recommendations for increased microbial management, resulting in more efficient use of resources and more sustainable production

Basic knowledge of the immune systems of aquatic vertebrates and invertebrates is urgently needed to develop appropriate measures for disease prevention and/or control. Now that model systems for use with aquatic organisms have become available, experts from similar research sectors working with terrestrial animals might realise the new research opportunities in the aquaculture domain.

Aquaculture is frequently criticised for having a negative impact on the environment, which tends to overshadow its contributions to fighting hunger and alleviating poverty. However, it is unjustified to reject aquaculture – instead we should intensify our efforts to increase its sustainability. Aquaculture is crucial in our pursuit of global food security and good human health, as it offers a source of food that is rich in protein, essential fatty acids and vitamins and minerals. Furthermore, it offers a way to boost development by providing jobs, improving people’s incomes and increasing returns on natural resource use. We must ensure that the sector continues to expand, along sustainable principles, to provide more people with food and income, especially in areas like sub-Saharan Africa, Latin America and Asia where hunger and poverty prevail.

Plenary Lecture II

Sector Management and Governance in Aquaculture: An Overview

NEIL RIDLER

Ridler, N. 2010. Plenary Lecture II. Sector management and governance in aquaculture: an overview. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

There is now a consensus that modern and successful aquaculture, whether small-, medium- or large-scale, depends on the private sector and the profit motive. Such aquaculture must entail a business orientation as with any enterprise. One of the most important reasons why entrepreneurs flourish in some jurisdictions but not in others is governance. Governance affects all business, whether aquaculture or any other. Business-friendly policies, such as security of property rights, enforcement of contracts, and macroeconomic and political stability are important to stimulate entrepreneurship and investment in aquaculture because they reduce risk and costs. Without respect for the rule of law and enforcement of contracts, aquaculture farmers have difficulty obtaining adequate inputs from suppliers and marketing products. Dissemination of new research and technology too depends on administrative and institutional frameworks. Good governance enhances aquaculture sustainability as it enables the sector to prosper over a long time period. The purpose of this review is to offer some insights into aquaculture governance. For this, it examines aquaculture governance from a global perspective, looking at the role of governments in administering and regulating aquaculture, including, licence procedures, possible strategies and policy instruments. It also analyses the role and responsibilities of other stakeholders, such as industry, non-governmental organisations and communities. It is hoped these insights can be useful in promoting an industry that is sustainable.

Sustainability of the sector implies technical feasibility, economic viability, environmental integrity and social licence. An economically viable and efficient, environmentally friendly and socially responsible aquaculture sector will benefit every member of society because of its associated invaluable environmental and social amenities. Thus, a second aim of this review is to build on countries' recent experiences to review the role that aquaculture has played in improving countries' socio-economic growth and development, and to discuss how governance instruments including policies, laws, regulations and effective partnership amongst stakeholders can lead to enhanced aquaculture's net benefits to society. "The Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000" (Bangkok Declaration) has already recognised that the potential of aquaculture's contribution to human development and social empowerment cannot be fully realised without consistent, responsible policies and goals, effective institutional arrangements and regulatory

frameworks, and improving co-operation amongst stakeholders at national, regional and inter-regional levels.

Aquaculture sustainability, the ultimate goal of governance, will be difficult without adequate investment in the sector. The importance of investment in aquaculture, was acknowledged by the “Bangkok Declaration” which stressed that adequate investment in aquaculture is essential for its future development. In addition to emphasising this importance, it identified several constraints of this investment, such as the risk and uncertainty associated with returns from investment in the sector, and made recommendations for addressing the issues involved.

Since the Declaration, research has been undertaken by the FAO and other institutions and individuals to address many of the issues, and laudable results have been achieved. However, a decade later some of the then identified constraints and some others which are not mentioned in the Declaration, have started to seriously impede aquaculture development. For example, water has become scarcer; available new sites for aquaculture have become more difficult to obtain; and environmental and ecological problems have magnified. As a result, greater regulation of economic activity, including aquaculture production has occurred, posing new challenges for investment in aquaculture and future growth of the sector. In addition, high levels of exposure to risk and uncertainty in aquaculture continue to restrict investment in aquaculture and stunt its development. The third objective of this review, therefore, is to evaluate the progress made in this area since the Bangkok Declaration, identify the factors that contribute to risk and uncertainty in aquaculture, discuss the methods of specifying the risk and uncertainty involved and analyse their consequences on aquafarmers’ investment decision-making. Its goal is also to outline alternative methods of managing and coping with risk in aquaculture and to examine ways of extending the availability of insurance cover for aquafarmers. In so doing, the role of government policies, institutions and regulations will be examined.

Plenary Lecture III

Maintaining Environmental Integrity Through Responsible Aquaculture: Constraints, Opportunities and Challenges

MAX TROELL

Troell, M. 2010. Plenary Lecture III. Maintaining environmental integrity through responsible aquaculture: constraints, opportunities and challenges. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The world's ever-growing population is eating more and more fish and the production of our oceans cannot keep up. The solution has so far been to complement fishing with farmed aquatic organisms, in large following the same development seen on land, i.e. moving from "hunting and gathering" to farming. Aquaculture is today considered the only viable option for meeting the increasing future demand for fish and seafood products. However, while aquaculture has provided economic and nutritional benefits to millions, there are concerns that unconstrained sectoral expansion and intensification, coupled with its ecological and social impacts, globalisation and fluctuation of markets and resources, climate change, etc. may have undesirable impacts on the resilience of social-ecological systems. For example, a significant part of the aquaculture expansion is expected to occur in coastal areas, where it directly affects natural resource systems already experiencing large pressure from human activities. Thus, depending on species, culture system and siting, there is a risk that anticipated benefits from aquaculture may come at the expense of increased pressure on ecosystem functions and services upon which poor people in particular depend for food security and livelihoods. Even if farming activities take place in offshore environments, intensification and the choice of aquaculture species that require condensed high-quality resource inputs (especially feeds) indirectly increases the dependence on provisioning services from both terrestrial and aquatic ecosystems at a global scale. It needs to be emphasised, however, that intensification may not in itself be negative, as it can be one way for aquaculture development to meet constraints on land/sea surface availability or the need to dissociate the farm system from the local environment to avoid negative effects from e.g. parasitic infestation.

The development of aquaculture has directly contributed to the loss of important ecosystem functions through land and seascape transformation, and also more indirectly through e.g. pollution. On the other hand, aquaculture has also enhanced provisioning services, both in the agriculture landscapes and in the seascape, thus leading to improved welfare. It also constitutes a substitute to today's terrestrial animal production, which for some sectors can be highly resource consuming. The question then is how to balance the negative and positive consequences from an environmental integrity perspective.

Looking at the diversity of farming systems, it is easy to understand that the biophysical impacts of aquaculture activities, i.e. magnitude and spatial scale, will vary enormously. Impacts could vary with species, culture system, intensity of production method and quality of management, and include issues such as: nutrient enrichment or depletion, effects of chemicals, disturbance or replacement of local ecosystems, exotic species introductions, flow of exotic genetic material from farmed to wild populations, transmission of disease/parasites, consumption of capture fishery resources, energy dependency and associated greenhouse gas emissions. To identify direct and indirect environmental effects from aquaculture activities, a wider system perspective is needed. Thus, it is not enough to discuss the local effects of aquaculture production in an analysis of the sustainability of the industry, as trade in a globalised world connects farms to distant ecosystems (and markets). A value chain approach, which captures up- and downstream activities (seed and feed production, distribution, processing, transport, etc.), follows an “ecosystem perspective” that extends far beyond the farm border (regional to global). Trade of final products and resources also increasingly interlinks different food production systems at the global scale. This does not only have implications for supporting resource systems, but volatility spillovers from e.g. the agricultural or fishery market can also have significant effects on vertically related markets such as aquaculture, resulting in increased vulnerability.

To meet future expected demands for food (i.e. protein), it is argued that aquaculture production will have to continue to expand, maybe at an even higher rate than seen today, as global capture fisheries is in decline. A relevant question to ask then is “what kind of aquaculture should be developed considering environmental and social implications and boundaries?”; but maybe we also need to more closely compare aquaculture with competing alternatives to find out which are the most sustainable options. Aquaculture represents only one of many avenues for providing food, and its strengths and limitations must be carefully considered. Such comparisons should be made not only to fisheries and livestock, but also to non-animal food products as well. The local/regional/global “space” available for aquaculture expansion should then also be weighted against other stakeholders’ (sectors’) access right across the entire socio-economic spectrum. A challenge here is to improve our understanding about ecosystems functions and the services they provide, i.e. about complexity and what structures and processes support and create resilience of these systems. This perspective implies acknowledging that uncertainties and nonlinearities exist and that these must be considered in management.

It is clear that the expansion of aquaculture will face many different challenges over the next decades, ranging from environmental, socio-economic and technological to policy-related challenges. From a general global perspective, the development of sustainable feeds will be put high on the research agenda; this is especially relevant for mariculture and brackishwater culture but will also be important for some freshwater fish species. The intricate interconnectedness with capture fisheries needs to be carefully evaluated, as well as aquaculture’s role in food security and the equitable distribution of resources. Recent positive trends in feed development for i.e. carnivorous fish species show the decreased need for inclusion of fish products and the development of alternative sources for proteins

and oils. It is, however, important that the feed development does not become a “problem shifting” development, i.e. that the pressure for protein-rich compounds is only being moved from the fishery sector to the agriculture sector. It is also important to acknowledge that maintenance of environmental integrity for sustainable development of aquaculture will require not only technical advances (e.g. ecotechnology) but also changes in the institutional framework (legal and policy frameworks, regulatory capacity, implementation mechanisms).

Aquaculture makes demands on, but also can provide a range of ecosystem services that are site, species, production system and culture method dependent. The question arises how best to guide the development of aquaculture in a region whose ecosystem services are increasingly under pressure from a combination of factors in order that it plays its part in developing and maintaining food production and/or a portfolio of livelihoods. Aquaculture systems practicing different forms of integrated techniques exist; both more extensive traditional systems and the more recently developed intensive systems. Integrated aquaculture is certainly not a panacea for aquaculture development but should be looked upon as one potential tool among many others facilitating sustainable development. These may improve performance with respect to local and regional impacts and from a global resource perspective, and also reduce the vulnerability associated with monoculture. Existing national and international “best management practices”, “codes of conduct”, “development criteria”, etc. developed to guide the industry and individual farmers towards sustainability seem to over-generalise and lead to qualitative goals, without specific means of measurement and monitoring. Sustainability is a broad concept, but even so it needs to be reduced to specific actions to be useful as an objective for ongoing development of aquaculture.

Aquaculture's potential for development, i.e. its operational space, is rapidly shrinking due to other human activities that either directly or indirectly prevent its prospect (i.e. pollution, space availability, etc.). Some forms of aquaculture may not be fulfilling the many criteria for sustainability (i.e. characterised as “not perfectly responsible aquaculture”) but in some situations, the environmental costs of not developing aquaculture as an alternative livelihood or food provider may be quite high. This is not to say that quick fixes always should be allowed, but that the consequences from inactions need to be analysed from the broader systems perspective.

Plenary Lecture IV

Responding to Market Demands and Challenges: Making Aquaculture a Competitive Food Producing Sector for the Benefit of World Consumers

LARA BARAZI-YEROULANOS

Barazi-Yeroulanos, L. 2010. Plenary Address IV. Responding to market demands and challenges: making aquaculture a competitive food-producing sector for the benefit of world consumers. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The last few years have been marked by increasing concerns about aquaculture as an environmentally sustainable activity. For an industry to be sustainable, however, it not only has to be environmentally sustainable with a low, measurable and controlled impact, but it must also be economically viable and socially acceptable.

The aquaculture industry globally is characterised by an apparently endemic cyclicity that goes beyond good or bad management and affects good companies and bad. This boom and bust cycle is especially disruptive in its social repercussions (job losses, loss of investor and other stakeholder confidence) and represents the most serious impediment to sustainable aquaculture development: an aquaculture company or farmer in financial difficulties can rarely afford to be conscious of environmental issues.

This is essentially a market issue: the most well managed, competitive, aggressive and innovative company will fail if it produces something the market doesn't want, in the wrong form, at the wrong price or in the wrong quantities. Understanding the market and responding to it are essential to the economic viability of any activity. The sustainability of aquaculture is now a question that is of increasing concern not only to the activity's stakeholders such as local and national authorities and NGOs, but also to consumers; addressing consumers' environmental or social issues is in essence, a market response. Understanding and evaluating the economic aspects of marketing is vital for building an effective marketing strategy as well as a coherent corporate vision.

This presentation aims to address the boom and bust phenomenon in the industry by examining some of the solutions that can help smooth out its cyclicity. The global aquaculture industry is a commodity market characterised by stiff competition and price volatility. The great majority of producers are small to medium-size enterprises (SMEs) with limited resources to invest in the promotion of their products, and the market is dominated

by a few large retail chains with demands for compliance to their own quality labels while paying ever decreasing prices that are not necessarily passed on to the consumer.

The role of information gathering, management and analysis for decision making is discussed. These are three different challenges that can be addressed on a company, industry and state level. The effective interpretation of market data is essential to the formulation of a coherent business plan and evaluation of the strengths and weaknesses of a particular product. In essence, the aquaculture industry globally has developed along two distinct lines: the modernisation and expansion of an existing, traditional farming method; and the creation of new industries based on technological advances. In terms of effective market placement, the activity in question (and its origin) can play an important role in so far as the consumers' acceptability and familiarity with the product is concerned. The marketing needs become different in each case.

Marketing is nothing more than communication that is targeted to a specific audience. The presentation will examine the different methods of communication available, as well as the target audience, the methods that can be used to effectively formulate the message and the key role of retailers in marketing. The trends that influence consumers' buying habits, the importance of quality certification to increase consumer confidence, and the role of logistics and distribution systems in improving quality and service are discussed.

Farmers generally face a commodity market where they have little bargaining power to negotiate either prices or transaction terms and are removed from the final consumer. Possible solutions such as production concentration can lead to greater market stability and therefore sustainability, but only if it is accompanied by greater cost efficiency and better production planning, i.e. production that is better coordinated with demand and better negotiation power vis a vis the market channels. An alternative strategy of concentration through cooperative action can be a means of achieving concentration of the offer without financial consolidation, allowing smaller, family-owned farms to retain their independence.

The use of collective action, either formal, such as producers organisations or informal, such as collectives, can be an important tool in helping farmers communicate more effectively with their final consumers. Good communication regarding producer activities, origin and production methods are necessary to transmit the benefits of aquaculture as an activity to consumers and promote both the production and consumption of responsibly produced seafood.

The presentation includes a brief review of the global market for aquaculture products and a review of the basic marketing aspects and principles, and will identify potential response strategies. A review of the general characteristics of the market for aquaculture products must examine the determinants of supply and demand, sources of competition and a qualitative analysis of consumers and their preferences, including contemporary market trends and consumer perceptions towards aquatic food consumption. The review of the basic market aspects and marketing principles looks at the structure of the market system,

market segmentation, consumer behaviour and price and supply elasticity. Response strategies to market challenges for the aquaculture industry are discussed based on a market-focused strategy and not on a production-oriented approach. The presentation looks at some of the lessons that can be learned from similar industries and present market and corporate strategies that can lead to a modern, competitive and most importantly, sustainable global aquaculture industry.

Plenary Lecture V

Improving Knowledge and Information Sharing, Research, Extension and Communication on Aquaculture

GARY L. JENSEN

Jensen, G.L., 2010. Plenary Lecture V. Improving knowledge and information sharing, research, extension and communication on aquaculture. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/ Thailand Department of Fisheries. Phuket, Thailand.

Aquaculture has transitioned rapidly over the past decade to reach global status as a critical source of nutritious and safe food. Aquaculture has a global menu of hundreds of species, with more anticipated. Production sites cover the salinity spectrum from seawater to freshwater, with traditionally dug ponds, input-dependent intensive systems, ocean and lake cage technologies, computer-operated recirculation tanks and more. The far reaching diversity creates vast opportunities and challenges to scientists, educators, managers and planners. Expansion, especially in developing countries, has realised extraordinary advancements and highlighted needs for improvement. Growth in productivity faces increasing pressures from land degradation, climate change, scarce water supplies and competition for input resources. Global demand will intensify incentives for expansion of culture areas and higher efficiencies in yields. Increases in production must occur in the context of environmental sustainability, social responsibility and new societal drivers. Opportunities abound, yet country-level constraints and economic outlooks will influence the pace of growth and location of future production areas.

Research, extension, policy and information systems are powerful mechanisms that must address several dimensions of food security at once. Sustaining a long-term trajectory of increasing production to meet future food security needs will depend on the ability of institutions to protect aquatic ecosystems amidst strong pressures for increased local consumption and international trade. Viable solutions will be expedited from collaboration among numerous public and private services that can integrate new discovery knowledge and information sharing, available credit and inputs, and global to local communications.

Impact-oriented research reaching farmers and consumers by motivated extension and outreach across enterprise scales is another critical service. Public education must not be overlooked for improving the image of and knowledge about responsible aquaculture. History reveals the short life of unsustainable development strategies. Such practices can be avoided with new decision-making tools and effective communication of case studies and lessons learned. Accurate and timely statistics on production value and volume, species and locations at national levels that can be aggregated for global trend analysis, market information systems and forecasting will aid public and private investments, development and trade policies.

Some challenges can benefit from reshaping research towards a new and different future and building new alliances and synergies to address many key elements articulated in the Bangkok Declaration and Strategy. Development goals require sustainable resources, diverse expertise, specific strategic objectives and targeted outcomes, such as reducing food insecurity. New fields of science and analytical tools are improving husbandry techniques, system operations, selective breeding, feed formulations and disease management. More scientific data on health benefits from fish consumption are also emerging. Virtual technologies and remote sensing are becoming powerful tools to aggregate diverse data sets for new field applications, including site planning for sustainable development among competing forces and complex scientific factors. Integrating expert systems into virtual environments and new modelling tools offer novel approaches for multidisciplinary planning and analyses.

Intuition-based aquaculture is being systematically replaced by science-based practices and improved technologies from world-class research institutions and new innovations by entrepreneurial farmers and private companies. Opportunities exist to improve research environments with stronger public-private networks and collaborative team-building. Open solicitations for new ideas can accelerate creativity to drive high technology through low technology applications. Pioneering scientific breakthroughs will emerge throughout the world; however, synthesis and translation are most often required for farm applications to create high-impact benefits from widespread adoption. Field-based or on-farm research and demonstration can engage farmers with realistic cost/benefit analyses for effective socioeconomic development processes. Farmer engagement facilitates solutions for farm-level problems and adoption of new practices with local economic, market and social relevancy and shortens time lags between research and deployment of new technologies. Stakeholder input and engagement ultimately set the trajectory of development. Rigorous evaluation and planning processes can align collective knowledge systems and limited resources across different programmes for strategic collaborative frameworks to solve complex and intractable problems.

With the immensity of evolving global demand for energy-efficient farmed aquatic animal protein, research and technology transfer institutions will require more resources and investments in training and equipment to develop the human resources capacity for advancing technologies, tools and practices to meet the challenges of expanding

sustainable aquaculture production. Ultimately, sustainable expansion depends on continued improvements of farm management driven by competitive forces among farmers and businesses and solving issues raised by societal and political systems. Innovation will be required to reach remote areas and gain acceptance of new technologies. Bilateral and multilateral collaborations are expanding through scientific, technical and policy exchange programmes narrowing information and scientific knowledge gaps. To meet global needs for food security and poverty alleviation in rural communities to thriving international markets, bold actions and tactics will be required by farmers, companies, academics, government officials and the public who collectively oversee and manage the world's natural resources and their bounty for human needs: in this case, food from farmed aquatic species. The sustainable availability of an adequate food supply and peoples' access to nutritious diets is largely dependent upon educated individuals, responsive institutions and an enabling environment that engages a broad range of stakeholders. With significant improvements in sustainable aquaculture productivity and development, the imbalances between aquatic food supply and demand may be overcome to decrease food insecurity, scarcity and price volatility over the coming decades.

Plenary Lecture VI

Enhancing the Contribution of Aquaculture to Poverty Alleviation, Food Security and Rural Development

MODADUGU V. GUPTA

Gupta, M.V., 2010. Plenary Lecture VI. Enhancing the contribution of aquaculture to poverty alleviation, food security and rural development. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

We are passing through an era of increasing population, food shortages and unsustainable farming practices. This will be exacerbated in the coming years by the global warming and climate change that will have an impact on the production of aquatic food. It has been estimated that 852 million or 14 percent of this global population are hungry and of these, 690 million are in Asia-Pacific, the region that contributes about 90 percent to global aquaculture production. Micronutrient deficiency is affecting more than 2 billion people globally. Fifty-seven percent of children suffer from vitamin deficiency. Over 1 billion under-nourished live in low-income countries. In this context, fish is considered as “rich food for poor” and the cheapest animal protein, and in many developing countries provides at least 20 percent of the animal protein intake for over 2.6 billion people. In addition, the aquaculture sector is directly providing livelihood to over 12 million people and to many

more million in support activities, besides generating much needed foreign exchange earnings through export of aquatic products.

We cannot think of food security unless issues connected with poverty and livelihoods are addressed. In this context, aquaculture has been and will be playing an important role in poverty reduction among rural populations through improvement/creation of livelihoods and income generation. Relative growth of aquaculture as compared to crop agriculture suggests that aquaculture can be a major rural growth sector. For example, in Viet Nam, 50 percent of the farmers involved in aquaculture derive on an average a 75 percent higher household income; tilapia farmers in the Philippines get around 50 percent higher income than rice farmers; in China, annual per capita income of people involved in the aquaculture sector is double the income of rural terrestrial farmers. Shrimp farmers in Viet Nam, grouper and seabass farmers in Indonesia, fish seed producers in Cambodia, seaweed farmers in Indonesia and the Philippines and prawn farmers in Bangladesh have shown that aquaculture can contribute substantially to household incomes and create livelihoods. Aquaculture of carps in India has generated additional employment opportunities for the landless in rural areas. It has been demonstrated that the involvement of women in aquaculture can lead to their empowerment, in addition to better nutrition for their families, especially children. It has been estimated that empowerment of women in Asia and Sub-Saharan Africa could improve the condition of 13.4 and 1.7 million undernourished children, respectively.

Aquaculture has grown tremendously in the last few decades, from less than a million tonnes per annum in the 1950s to over 50 million tonnes in 2008, and is expected to meet the increasing demand in the coming years. However, the annual growth of aquaculture has declined from 11.8% percent in 1985–1995 to 7.1 percent during the next decade and to 6.1 percent during 2004–2006. Further, environmental problems are increasing and the number of small farms is decreasing, threatening the livelihood of small farmers.

Since 75 percent of global aquaculture production comes from small-scale farms in developing countries involving poor rural households and landless, we have to address a number of issues to ensure that the livelihoods and food security of all those involved in the sector are not threatened, but that aquaculture also contributes to the food and nutritional security of the countries. Some of the issues that need to be addressed to ensure that small-scale aquaculture are sustainable, contributing to food security, poverty alleviation, rural development and enhanced livelihoods, are given below. Of the total aquaculture production, nearly 75 percent is contributed by freshwater aquaculture (excluding the aquatic weeds). Currently, the finfish being cultured in marine environment are high-value carnivores that need animal protein in their diets, making their culture too expensive/capital intensive for small farmers to be a part of the development of the sector.

Science relevant to needs of small-farmers: The observed high yield gap between farmers' productions and the potential from improved technologies indicates that it is necessary: (i) to develop technologies that can be easily adopted by the farming community;

and (ii) to utilise the communication technologies that are opening new opportunities for knowledge and information sharing between researchers and farmers.

Aquaculture in the context of rural development: Small-scale rural aquaculture should be seen from the perspective of rural development and not as a stand-alone activity and be incorporated with other farming activities. With availability of land and water becoming scarce, sustainability of extensive or low-output aquaculture is threatened. It is necessary to equip the farmers with the latest technologies for higher per unit production.

Seed and seed certification: In spite of the availability of induced breeding technology for over five decades, aquaculture of some species, especially the marine finfish, depends on wild seed supply. Hatchery seed production technologies need to be developed for some of the high-value species; in freshwater aquaculture, inbred seed from hatcheries is leading to low productions; there is need for seed certification in most of the major aquaculture-producing countries.

Application of biotechnology: Unlike in the case of crops and livestock, less than four percent of aquaculture production comes from improved breeds. There is an urgent need for application of genetics and biotechnology in aquaculture species and to develop improved breeds for aquaculture. At the same time, it is necessary to ensure that these improved breeds/strains are accessible to small-scale farmers.

Disease management: Disease outbreaks crippled freshwater aquaculture in 1980s and coastal aquaculture in 1990s, causing losses amounting to billions of dollars. With the expansion and intensification of aquaculture in the coming years, fish health management needs to be given greater importance through developing diagnostic kits for more species and diseases and setting up diagnostic laboratories in areas with high aquaculture activities.

Feeds and feeding: Feeds constitute about 40–60 percent of total costs in aquaculture. Mariculture and intensive culture systems depend on fishmeal and fish oil in their feeds. Shortages and increasing costs threaten the industry. There is a need to look for alternate vegetable proteins to replace the animal proteins in the fish feeds and also to develop culture techniques for more herbivores and filter feeders.

Food safety and product quality: Rising market standards in terms of food safety, quality, traceability, certification and ecolabelling should not form a barrier or additional impediment for entry of products produced by small-scale farmers. Farmers need to be informed and trained to comply with food safety standards set by domestic and export markets.

Micro-credit: Lack of access to credit from public-sector banks has been a constraint for small-scale farmers. Micro-credit delivery is needed for (e.g. in Bangladesh) motivated small farmers to take up new technologies and increase productions.

Involvement of landless: Excellent opportunities exist for the involvement of rural landless in culture-based capture fisheries in wetlands, reservoirs, ox-bow lakes, etc., as has been demonstrated in a number of countries in Asia.

Culture of non-food species: Culture of ornamental fish and seaweed farming offer excellent opportunities for small farmers to take advantage of the huge market without much investment and can create livelihoods for rural and coastal poor.

Markets and marketing: Small farmers are not able to get needed inputs at reasonable prices and lack bargaining power to market their products. Further, stringent food safety and product quality requirements of domestic and export markets make individual small farmers vulnerable. It is necessary to develop BMPs for a greater number of aquaculture species. As has been demonstrated in some of the countries of Asia, formation of farmers' associations/ cooperatives/clubs has resulted in farmers being able to negotiate input prices, get better prices for their products and minimise environmental impacts.

Policy: Fisheries has been mainstreamed into national policy documents relating to poverty reduction and rural development. However, allocation of adequate resources (human and financial) by governments is needed for these policies to bear fruit. To encourage aquaculture growth, it is necessary for the governments to treat aquaculture on par with agriculture for subsidies, tariffs for power and water, taxation, etc.

Invited Guest Lectures

Ballroom

Invited Guest Lecture I

Is Feeding Fish With Fish a Viable Practice?

ULF N. WIJKSTRÖM

Wijkström, U.N., 2010. Invited Guest Lecture I. Is feeding fish with fish a viable practice?. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The use of fish as feed for aquaculture is not uncontroversial. Some say that the practice should be reduced, if not stopped. They argue that the practice is not in the interest of those consumers who otherwise would have eaten the fish used. The amount of fish available is reduced as more than one kg of fish – in the form of feed – is needed to grow one kg in captivity. Also, the ever expanding demand for fish as feed is thought to endanger the long-term sustainability of targeted fish stocks.

Capture fisheries produces some 90 to 95 million tonnes of fish and other aquatic species per year. Of these somewhere between 20 and 25 million tonnes are regularly processed into fishmeal and oil. During the last two decades, a growing portion of the world's fishmeal and oil has been bought by the fish/shrimp feed industries and converted into fish and shrimp feed. Most of the 25 to 30 million tonnes are obtained by industrial fisheries in the North Atlantic and in the Pacific Ocean off the west coast of South America.

In China, Southeast and South Asia, by-catch, particularly from trawl fisheries for shrimps, are used as fish feed. There are no precise estimates of the quantities involved, but it is believed that they may be of the order of 6 million tonnes of fish per year. Also, whole or chopped fish is used in growing quantities to feed captured juveniles of bluefin tuna.

It is an undisputable fact that modern farming of carnivorous fish and shrimp uses more fish as feed than is produced as finfish or shrimps; that is, the ratio between fish used and fish obtained is higher than one. However, if the fish used as feed is not consumed as food (for whatever reason: not appetising, too bony, too small or because it is not economically viable to preserve it for later consumption), then in the end, might not its use as feed lead to more foodfish?

The author shows that industrial fishing for forage species in the North Atlantic and in the Pacific, off the coast of South America, via manufacture of fishmeal and fish/shrimp feeds, brings about a net contribution of foodfish supplies, without causing a systematic collapse of the exploited forage species. However, the practice of using bycatch as fish/shrimp feed has apparently led to a decrease in the availability of fish as food for the very poor

in some regions of South, Southeast and East Asia although this affirmation needs to be substantiated with hard data.

Also, it should be recognised that, a large part of the “forage fish” used to produce fishmeal is edible fish. If this fish could be made available as low-cost food to the poor, no doubt their food security would improve. The obstacles for such a development are economic and legal. On one hand, a global agreement under the WTO would be needed authorising the sale of “food grade” subsidised food-quality forage fish and, secondly, an internal fund would have to be created to finance (at the rate of billions of US\$ per year) the production, storage and transport of cheap fish products based on “food forage fisheries” in the North Atlantic and Southeastern Pacific.

True, the practice of feeding fish to fish/shrimps leads to more foodfish being available for human consumption, but who will be able to afford the additional supplies? Most of the species that are fed with feeds that include substantial portions of fishmeal and fish oil are not low-cost items. It can be safely argued that these species will not be become a regular component in the diet of the poor, and particularly not of the poor in developing countries.

On the other hand, aquaculture today contributes about half of all the seafood eaten in the world. Doubtlessly the real price of all fish would have been substantially higher today, had not aquaculture existed. This will have benefited also the very poor. Naturally all the merit of this development does not lie with the use of fish as feed, as not all aquaculture systems use feed or fish, in one form or another, as feed.

The author ends by considering an aspect that is often neglected in the discussion of the use of fish as feed for fish: employment. Most governments see unemployment as a problem. They work to support the creation of employment. Thus, employment in feed fisheries, fishmeal/fish oil industries, fish/shrimp feed industries and aquaculture is a positive contribution.

The author identifies shrimp farming as a labour-intensive activity that provides employment to millions of unskilled workers in developing economies. In the absence of fishmeal/fish oil, most of those employment opportunities most likely would cease to exist.

Invited Guest Lecture II

The Role of Aquaculture in Healthy Communities

MELANIE SIGGS

Siggs, M., 2010. Invited Guest Lecture II. The role of aquaculture in healthy communities. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Fish makes a vital contribution to the survival and health of a significant portion of the world's population. Fish is especially important in the developing world. In some of Asia's poorest countries, people derive as much as 75 percent of their daily protein from fish. In West Africa, fish accounts for 30 percent of animal protein intake, and this number would be larger if the poor could afford to buy more. However, with a significant percentage of the world's fisheries over exploited and a highly complex international trade in seafood, the continued expansion of fish farming (aquaculture) – an ancient and traditional practice – may offer a real contribution to the supply, diets and economies of producer nations' communities throughout the world. In spite of this potential to address nutritional and economic issues in rural development, aquaculture is often over looked by governments, and even philanthropic foundations, in their policies and planning processes.

During the course of this paper, it is intended to discuss a number of potential attributes that aquaculture can bring to communities in developing countries to address the potential of fish as a ready provider of essential nutrients, a tradable commodity and as such, a contributor to development and social stability. Beyond this, the author will seek to raise and explore some of the key challenges and issues associated with this development opportunity and inquire as to how they might be positively addressed. If aquaculture was to become more of a front line in rural development and communities, what considerations might regulators need to take to ensure responsible, sustainable and financially viable practices that contribute to poverty reduction and nutritional improvement?

Food security: According to FAO food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. With global populations rising, climate change altering the production opportunities and first nations continuing to take precedence on food distribution, aquaculture may offer an alternative, viable food source that can be produced, traded and consumed either on a micro or macro level. However, the environmental challenges of good aquaculture practice are complex and the question of how to ensure development is forward thinking and responsible continues to concern both social and environmental thinkers.

Economic opportunity: Demand for food, whether for subsistence or luxury, will continue. This in turn offers revenue for producers. As aquaculture is the fastest growing food commodity in the world, de facto the opportunity for economic development must surely exist on many levels. However, what are the implications of economic opportunity in terms of a desire for intensive production, cheap labour, land and water rights and energy costs? How can positive development be best supported to enable good business while mitigating these key environmental and social issues?

Healthy societies: The need for good protein sources and omega-3 fatty acids to ensure healthy children and adults alike is well documented. Strong evidence shows that omega-3s are essential for good brain development and likely responsible for the human brain's evolutionary size and capacity. Further the author suggests that where there is a consistent supply of food and employment better opportunity also exists to enable stronger communities and families. Sometimes deemed "the" food security issue, a lack of food can result in violence and disorder. Moreover if the supply of food is at a level that can be traded, even at a local level, and provide income, then the potential for expanded community development is great; for example, collaborative investment in schools and health care provisions.

Certainly aquaculture appears to offer a myriad of opportunities and benefits to communities in developing countries and broader rural development. However, we have seen how this can lead to environmental and even social breakdown over resource and human rights, and as such the author proposes that it is our collective responsibility to continue to identify these risks and to work with communities for collaborative solutions and best practice plans that will enable and support these communities in their aquaculture development process, both now and long into the future. Governments can play a key role in enabling responsible best practice, while aid agencies and philanthropic support might do well to include appropriate aquaculture development in their portfolio of programmes, beyond agriculture.

Invited Guest Lecture III

Coping With Climate Change: A Real Challenge to Aquaculturists?

SENA S. DE SILVA

De Silva, S.S., 2010. Invited Guest Lecture III. Coping with climate change: A Real Challenge to Aquaculturists? Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

In spite of all the debates and controversies, a global consensus has been reached that climate change is a reality and that it will impact on food production systems, among others, in diverse manifestations ranging from increased global temperature, to sea level rise, to more frequent occurrence of extreme weather events, to change in weather patterns such as the monsoonal rain patterns. In this regard, aquaculture is no exception. Aquaculture – farming in the waters – is also characterised by the fact that the organisms cultured, the most diverse of all farming systems, are all poikilotherms. It occurs in fresh-, brackish- and marine waters, and is spread across all climatic regimes from temperate to the tropics. Consequently, there are bound to be many direct impacts on aquatic farming systems brought about by climatic changes. The situation is further exacerbated by the fact that certain aquatic farming systems that also happen to be significant in commodity value, such as salmonid and shrimp farming, as well as those of relatively low commodity value but undergoing increasing intensification, are dependent, to varying degrees, on products, subjected to reduction processes, from the wild. All of the above factors will impact on aquaculture in the decades to come and accordingly, the aquatic farming systems will begin to encounter new challenges to maintain sustainability.

The challenges that aquaculture will face will vary to a significant degree between climatic regimes. In the tropics, the main challenges will be encountered by those farming activities that occur in deltaic regions, which also happen to be hubs of aquaculture activities, such as in the Mekong Delta and the Red River Delta in Viet Nam and the Ganges-Brahmaputra Delta in Bangladesh. Aquaculture activities in tropical, deltaic areas will be mostly impacted by sea level rise, and hence increased saline water intrusion and reduced water flows, among others. Perhaps, as a mitigating measure there could be a need to shift to more salinity-tolerant species or to develop higher salinity-tolerant strains, as the case may be. Elsewhere in the tropics, inland cage culture and other aquaculture activities could be impacted upon by extreme weather conditions, increased upwelling of oxygen poor waters in reservoirs, etc., requiring greater vigilance and monitoring, and even perhaps readiness to move the operations to more conducive areas in a water body.

Other indirect impacts of climate change on tropical aquaculture could be manifold and perhaps largely unknown. The reproductive cycles of a great majority of tropical species are dependent on the monsoonal rain patterns, which are predicted to change. Consequently, irrespective of whether cultured species are artificially propagated or not (the great bulk are), the change in the reproductive cycle will impact on seed production and thereby, the whole grow-out cycle and modus operandi and management of farm activities. Equally, such impacts will be felt on the culture those species that are based on natural spat collections, such as molluscs.

In the temperate region, global warming could raise the culture temperatures of some species to the upper tolerant range and thereby make such culture systems vulnerable to high temperatures, the mitigating measures available being either to shift to other species with high temperature tolerance and/or to develop strains tolerant to higher temperatures. In the temperate regions, there is a high possibility of new or dormant pathogens becoming virulent with increase in water temperature, confronting the sector with the need to combat new or hitherto un-manifested diseases.

Climate change may also cause indirect effects on aquaculture via impacts on production of those fish species that are used for reduction and which, in turn, form the basis for feeds in aquaculture, particularly for cultured carnivorous species. This is likely to have a major impact on some key aquaculture practices, spread across all climatic regimes. Limitations of supplies of fishmeal and fish oil, and the resulting expected exorbitant price hikes of these commodities, will lead to more innovative and pragmatic solutions on ingredient substitution of aquatic feeds, which perhaps will be a positive result arising from a dire need to sustain a major sector.

The sector has to be proactive and start working on adaptive and mitigating measures, sooner rather than later. Adaptive and mitigating measures to sustain the sector in the wake of climate change impacts will entail both technological and socio-economic approaches. The latter will be more applicable to small-scale farmers, the great bulk of producers in developing countries who constitute the backbone of the sector, contributing perhaps in excess of 70 percent of the global aquaculture production. The sociological approaches will entail the challenge of mitigating the potential climate change impacts on small farming communities, in the most vulnerable areas, such as in deltaic regions, and weighing the most feasible adaptive options and bringing about the policy changes required to implement those adaptive measures economically and effectively.

Global food habits have changed over the years. We are currently in an era where food safety and quality, backed up by ecolabelling are paramount; it was not so 20 years back. We will in the very foreseeable future move into an era where consumer consciousness will demand that farm foods of every form, when they reach the table, should have a minimal green house gas (GHG) emission level; the price and demand will be determined by such a factor. Perhaps the greatest challenge faced by aquaculture is to meet these aspirations, and even as it is today, to impress upon the public that the great bulk of aquaculture

produce, for example about 70 percent of all finfish and almost 100 percent of all molluscs and seaweeds are minimally GHG emitting, and to continue the trend to drive aquaculture as the most green house gas friendly food source that is before us, and that the sector could still conform to such needs and continue to meet the increasing foodfish supply needs of the globe.

Expert Panel Presentations

Ballrooms I & III

Expert Panel Presentation I.1

Responsible Use of Resources for Sustainable Aquaculture

LEAD PANELLIST: B.A. COSTA-PIERCE

PANEL MEMBERS: D.M. BARTLEY, P. BUENO, F. GREENHALGH, M. HASAN, R. HASHIM, A.J. HERNÁNDEZ, D. HERRNANDEZ, J. HINSHAW, J.K. JENA, S.J. KAUSHIK, D. LEMOS, K. RANA, J. RUTASIRE, A. YAKUPITIYAGE

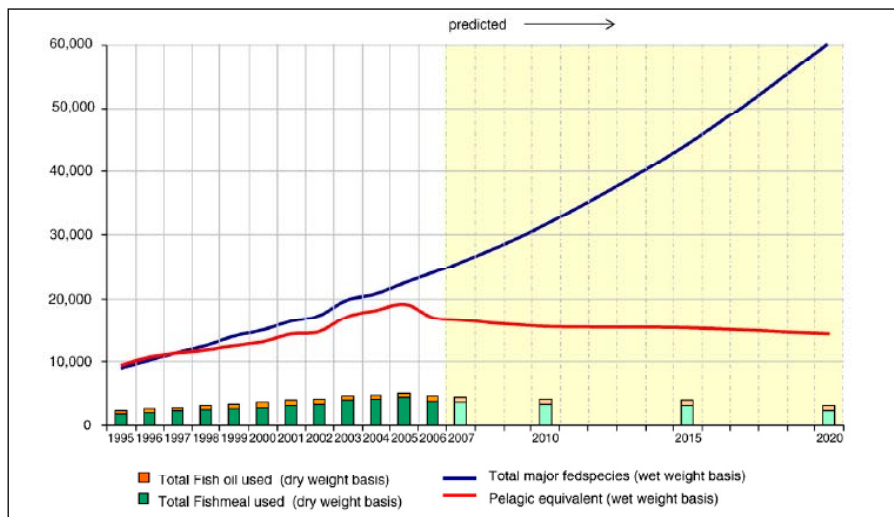
Costa-Pierce, B.A., Bartley, D.M., Bueno, P., Greenhalgh, F., Hasan, M., Hashim, R., Hernández, A.J., Herranandez, D., Hinshaw, J., Jena, J.K., Kaushik, S.J., Lemos, D., Rana, K. Rutaisire, J. and Yakupitiyage, A. 2010. Expert Panel Presentation I.1. Responsible use of resources for sustainable aquaculture. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The Bangkok Declaration expressed the need to develop resource-efficient farming systems that make efficient use of water, land, seed and feed inputs by exploring the potential for commercial use of species feeding low in the food chain and fully utilising enhancement techniques. Key resources that are used in aquaculture and a summary of how each has changed over the last decade are summarised in a table below.

During the past decade, resource use in aquaculture began to be measured in terms of FIFO (Fish In Fish Out) ratios and by measuring efficiencies in water, land use and carbon footprinting as new metrics for measuring resource efficiency and stewardship. Studies indicated finfish aquaculture of tilapia, catfish and *Pangasius* catfish taken together were comparable to poultry farming in terms of FCRs (1.8 vs. 2.0), water (2,800-6,300 litres/kg vs. 3,500–4,000), land use efficiency (7,941 vs. 7,946 kg/ha/year), and carbon footprint 2.0 vs. 1.8 kg CO₂/kg product).

A decade ago, published values of FIFO were as high as 5 kg. Rapid advances in aquaculture feeds, feed management technologies and nutrition science have decreased FCRs to ~1.5:1 for farmed marine fish and ~1.2:1 for farmed salmon. Thus, overall FIFO calculations indicated that global aquaculture now has a FIFO ratio of 0.52 (e.g. that for each tonne of wild fish caught, aquaculture produced 1.92 tonnes of aquaculture products), despite some groups as salmonids, eels, marine fish and shrimp still having an FIFO >1. Current projections are that over the next decade, fed aquaculture will use even less marine fish meals/oils, while overall aquaculture production continues its rapid growth. Just recently, EWOS announced that it will be accelerating research to measure the “marine protein and oil dependency ratios” for farmed species, with the goal of reducing these to less than 1.0.

Pelagic fish harvested and fed to aquaculture systems is predicted to decline while aquaculture production grows rapidly from 2006 to 2020 (from Tacon and Metian (2008))



Constraints to the expansion of global aquaculture are different for fed and non-fed aquaculture. Over the past decade for non-fed, shellfish aquaculture there has been a remarkable global convergence around the notion that user (space) conflicts in shellfish aquaculture can be solved due not only to technological advances, but also to a growing global science/NGO consensus that shellfish aquaculture can “fit in” in an environmentally and socially responsible manner, and into many coastal environments, the vast majority of which are already crowded with existing uses. Factors contributing to this are the: (a) development of submerged technologies; (b) scientific findings and reviews demonstrating the environmental benefits of shellfish aquaculture in providing vital ecosystem and social services such as nutrient removal and habitat enhancement; (c) research on natural and social carrying capacities for shellfish aquaculture and sophisticated, collaborative work group processes; (d) development of, and wide use by industry of better management practices; (e) diversification of traditional wild-harvest fishing/shellfishing families into shellfish aquaculture as part-time enterprises, breaking down barriers between fishing/aquaculture user communities; and (f) publication of global comparisons with fed aquaculture indicating a strong movement in shellfish aquaculture towards an adoption of ecological approaches to aquaculture at all scales of society.

Over the past decade, new, environmentally sound technologies and resource-efficient farming systems have been developed, and the integration of aquaculture into coastal area and inland watershed management plans has been achieved, but are still not widespread. These aquaculture ecosystems are highly productive, semi-intensive enterprises that are water and land efficient, and are net energy and protein producers that follow design

Key resource usage in aquaculture, issues associated with their use and trends in use from 2000 to 2010

| Resources | Issues | Trends |
|-----------|---|---|
| Land | Ponds have high land use in comparison to terrestrial agricultural protein production systems | Ponds being taken over by urbanisation; cage systems proliferating and trend towards submergence; intensive, recirculating systems are more efficient (ha/tonnes production) than terrestrial animal production systems; efficient integration of aquaculture into landscape-scale systems of mixed aquaculture/land uses; better land use planning addressing land/water user conflicts |
| Water | Severe water competition with alternatives; High water use in comparison to terrestrial agricultural protein production systems | Freshwater use conflicts and droughts increasing in production areas; rapid decreased costs/increased efficiencies of intensive, recirculating systems that use water more efficiently than terrestrial animal production systems; multiple uses of water in landscape-scale systems of mixed reservoir production with downstream aquaculture/agriculture; widespread integration of rice/fish systems in Asia; development of seawater farming systems in arid areas; development of low energy membranes with wind turbines breaking the 2kW/hr/m ³ barrier |
| Energy | High energy use in comparison to terrestrial agricultural protein production systems | LCAs showing advantages of aquaculture (> edible energy out of 10 kg of capelin if used as feed for farmed salmon (~28 MJ), than if eaten by cod that then is caught by fishing boats and sold on the markets (~3 MJ)) |
| Seed | Inadequate and unreliable supply of quality seed; poor genetic quality of seed; basic production from regional hatcheries – the human infrastructure, financial and business/marketing support and policy and legal frameworks are not in place in many nations; impacts of uncontrolled releases of cultured seed stocks | Rapid expansion of export-oriented international seed trade esp. of high-value species; increasing needs to introduce quality assurance measures beyond simple official zoosanitary certificates; Regional hatchery infrastructure taking shape in many nations |
| Feed | Overuse of marine meals/oils threatening sustainability of pelagic fish stocks; social equity/poverty concerns with use of pelagics as feeds rather than as direct human foods; contamination | Increased use of imported fish meals/oils for formulated feeds in Asia, esp. China, decreasing FCR, but increased use of wet feeds in carp polyculture systems with high FCR (>3.0) resulting in deterioration of water quality; decreased use of marine meals/oils in intensive systems and improvement in FCRs; replacement by agricultural sources of meals/oils and by algal/bacterial/fungal bioreactors; use of biotechnology to elongate/upgrade essential fatty acids; cleansing of oils by high technology |

principles similar to those used in the fields of agroecology and agroecosystems. Good examples exist for both temperate zone and tropical nations with severe land, water and energy constraints. In Israel, highly efficient, landscape-sized integrations of reservoirs with aquaculture and agriculture have been developed, as well as highly productive, land-based aquaculture ecosystems for marine species. In Canada, development of integrated mariculture systems (IMTA) for environmental mitigation has led to studies showing greater economic returns and social acceptability for large-scale industrial aquaculture. Siting of cages in enclosed seas such as the Mediterranean Sea remains controversial, especially when it has been estimated that cage aquaculture facilities contribute ~7 percent of the TN and ~10 percent of TP discharges in the sea. Inappropriate siting of cages has been blamed for the destruction of nearshore and benthic aquatic ecosystems over the past decade; however, recent studies have found that if cages are sited above seagrasses, that seagrass meadows can respond positively to aquaculture discharges with no impacts on benthic biodiversity, raising the possibility that a systems approach for large-scale fish production and environmental improvement is possible.

Expert Panel Presentation I.2

Novel and Emerging Technologies: Can They contribute to Improving Aquaculture Sustainability?

LEAD PANELLIST: CRAIG L. BROWDY

PANEL MEMBERS: GEOFF L. ALLAN, THIERRY CHOPIN, GIDEON HULATA, ALESSANDRO LOVATELLI, ZHANJIANG LIU, THALES PASSOS DE ANDRADE, RUI PEREIRA, SHAWN ROBINSON, MUKI SHPIGEL, CHRISTINA SOMMERVILLE, VAZHIYIL VENUGOPAL, CHARLES YARISH

Browdy, C.L., Allan, G.L., Chopin, T., Hulata, G., Lovatelli, A., Liu, Z., Passos de Andrade, T., Pereira, R., Robinson, S., Shpigel, M., Sommerville, C., Venugopal, V. and Yarish, C. 2010. Expert Panel Presentation I.2. Novel and emerging technologies: can they contribute to improving aquaculture sustainability? Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Aquaculture continues to be the fastest growing food production sector, representing great potential to meet projected protein needs of world populations. As aquaculture expands, examples demonstrate potential to improve economic and social wellbeing while producing needed wholesome food. On the other hand, some less responsible development has drawn attention to potential problems with social, environmental and financial sustainability. The scientific and business communities have responded to these challenges and opportunities with research efforts generating novel technologies mirroring the diversity of the industry.

In genetics and breeding, the pace of advancement and innovation has been increasing exponentially. Although >20 percent of aquaculture production today derives from selective breeding programmes, many successful sectors are now based on selection programmes including trout, salmon, tilapia and shrimp. The number of breeding programmes, diversity of species, target traits and efficiency and sophistication of techniques applied continue to expand and advance. Tools for exploring the genetic code including marker technologies, genome mapping, and even full genome sequencing are being applied to aquaculture species. Improved sequencing genetic libraries are enabling genomic tools to explore responses to disease, metabolic processes and production traits. Gene transfer techniques have been applied to aquaculture species, and enhancement of growth, disease resistance and cold tolerance has been demonstrated. However, the pace of scientific development has at times outdistanced our ability to analyse risks and benefits, develop appropriate culture and containment technologies, educate and communicate, and reach policy and regulatory consensus. Now more than ever, efforts must be made for society to accurately analyse and understand risks, to enable opportunities to raise healthier fish faster with less environmental impact while improving economic stability and providing associated social benefits.

Disease outbreaks continue to constrain aquaculture sustainability. Improvements in aquatic animal health are coming from new technologies and improved management strategies. Better understanding of the genetic and physiological basis of immunity is enabling the breeding and husbandry of cultured stocks for improved disease resistance. Vaccine development is benefiting from better specific antigen determination, more efficacious adjuvants and enhanced vaccine delivery. Traditional diagnostic technologies and newer methods including immunodiagnosics, fluorescence antibody, ELISA, immunochromatography and nucleic acid-based approaches such as in-situ hybridisation, PCR and qPCR have greatly improved speed, specificity and sensitivity. As the sophistication of the tools and access to on-farm rapid diagnostics improve, expanding training, infrastructure and certification of aquatic veterinary and pathology support grows in importance. Research on improving oral delivery and control of active ingredients, new medical products from plants, vaccination and integration of disease management strategies that focus on prevention offer opportunities for improved control of pathogens in the future, obviating the use of antibiotics and chemotherapeutants. The use of multiple tactics against infection, farm-based strategies, improved local availability of healthy stocks, effective regulation of drugs and chemicals and policies to minimise disease transfer will be major steps towards sustainability.

An important key to the culture of any fed species is the development of a sustainable, cost-effective and nutritionally complete feed. Research has focused on shifting from formulations based on ingredients to strategies based on nutrient availabilities and specific requirements. Continuing cost pressures and the acute need to replace the high levels of fish meals and fish oils in many aquaculture feeds are driving a transition to more sustainable feeds. Fish meal extension in aqua feeds requires a blend of technologies to meet high protein and specific amino acid requirements, supply essential fatty acids and

overcome lower tolerance to carbohydrates and anti-nutritional factors, while maintaining palatability and physical properties. Development and testing of water-stable sources of crystalline amino acids, organic minerals that do not bind with agonists like phytic acid, attractants and effective oil blends are all part of emerging solutions. Protein concentrates and enzyme or heat pre-treatment, and the use of genetically selected feedstuffs with reduced anti-nutritional compounds will provide options for formulators. High-quality rendered animal products can be an excellent source of protein and lipid if regulatory policies and market education enable use. New sources of proteins and oils from algae and microbes can offer alternatives as cost efficiencies improve. Use of enzymes, probiotics and prebiotics, phytochemical compounds and organic acids are being shown to change gut microflora and improve health, digestibility and performance. Improved pelleting and extrusion technologies along with attention to fine grinding, pre-treatment, manufacturing and drying temperatures distinguish top quality feeds. Application of post-pelleting technologies such as vacuum coating has allowed feed production with higher lipid content and enables addition of enzymes, attractants, carotenoids and other heat-labile supplements. Expanding use of floating feeds for top-feeding fish can improve sustainability by increasing efficiency of delivery.

Production systems technology advancements are also contributing to sustainable industry expansion. Recirculation technologies are improving with automated life support systems, improved waste recycling, specialised feeds and better efficiencies based on sustainability metrics. Shellfish production research is advancing reproductive control, larval production, health, predator deterrence and bio-fouling control. Cage production is benefitting from improved automation, integrated disease and parasite control, advanced engineering, feeds and feeding systems, and monitoring of environmental performance. Technologies for rearing disease-free, genetically improved shrimp and tilapia in reduced exchange biofloc-based pond and tank systems enable in-situ cycling of wastes, improving feed conversion efficiency, and reducing environmental impacts while enhancing biosecurity, health and cost efficiencies. Research work on integrated multitrophic aquaculture focuses on application of ecosystem-based approaches to integrate fed aquaculture (e.g. finfish) with organic extractive aquaculture (e.g. shellfish) and inorganic extractive aquaculture (e.g. seaweeds). All of these production system technologies are benefitting from expanding information and communication systems that are enabling advances in every stage of production. These and other examples suggest some of the benefits that future scientific-based innovation will contribute towards meeting increasing food demands, while improving social, environmental and financial sustainability of the global aquaculture industry.

Expert Panel Presentation I.3

Providing High Quality Feeds for Aquaculture and Getting Out of the Fish Meal Trap: Opportunities and Challenges

LEAD PANELLIST: ALBERT G.J. TACON

PANEL MEMBERS: GEOFF ALLAN, SIMON J. DAVIES, ABDEL-FATTAH M. EL-SAYED, MOHAMMAD R. HASAN, ANDREW JACKSON, SADASIVAM J. KAUSHIK, SANTOSH P. LALL, SERGIO NATES, WING-KEONG NG, NGUYEN THANH PHUONG, VICTOR SURESH, SUPIS THONGROD, MARIA TERESA VIANA

Tacon, A.G.J., Allan, G., Davies, S.J., El-Sayed, A-F.M, Hasan, M.R., Jackson, A., Kaushik, S.J., Lall, S.P., Nates, S., Ng, W-K., Phuong, N.T., Suresh, V., Thongrod, S. and Viana, M.T. 2010. Expert Panel Presentation I.3. Providing high quality feeds for aquaculture and getting out of the fish meal trap: Opportunities and Challenges. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The rapid growth of finfish and crustacean aquaculture has been due in part to the availability and on-farm provision of feed inputs within the major producing countries. If the aquaculture sector is to maintain its current average growth rate of 8 to 10 percent per year to 2025, the supply of nutrient and feed inputs will have to grow at a similar rate. While this may have been readily attainable when the industry was still in its infancy, this may not be the case in the future as the sector matures and grows into a major consumer and competitor for feed resources.

It is estimated that about 29 million tonnes of farmed fish and crustaceans (44.5 percent of the total global aquaculture production in 2007) is dependent upon the supply of external nutrient inputs provided in the form of fresh feed items, farm-made feeds or commercially manufactured feeds. Total industrial compound aquafeed production has increased over three-fold from 7.6 million tonnes in 1995 to 27.1 million tonnes in 2007, with production growing at an average rate of 11.1 percent per year. Aquafeed production is expected to continue growing at a similar rate to 70.9 million tonnes by 2020. Although current estimates for industrially produced aqua-feed production for the period 2007–2010 vary between 24.4 and 28.9 million tonnes, aquafeed volume represents only 4 percent of total global animal feed production of over 708 million tonnes in 2009. In contrast to compound aquaculture feeds, there is no comprehensive information on the global production of farm-made aquafeeds (estimated at between 18.7 and 30.7 million tonnes in 2006) and/or on the use of low-value trash fish or forage fish species as feed, with current estimates for China in 2008 ranging between 6 and 8 million tonnes.

Feed-fed aquaculture production and in particular, the production of higher trophic level finfish and crustaceans (shrimp, salmonids, marine finfish, eels, etc.) are largely dependent

upon capture fisheries for their major dietary source of protein and lipid. For example, in 2007 the aquaculture sector is estimated to have consumed 3.84 million tonnes of fishmeal (68.4 percent of total global fishmeal production) and 0.82 million tonnes of fish oil (81.3 percent of global production for that year). However, despite the continued dependence of aquaculture production upon the use of fishmeal and fish oil, there is wide variation in fishmeal and fish oil usage between major producing countries for individual farmed species. This variation mainly reflects differences between countries concerning the selection and use of fishmeal and fish oil replacers from plant sources or the use of land animal proteins and fats within feeds for high trophic level fish species and crustaceans.

In total usage terms, it is expected that the use of fishmeal by the aquaculture sector will decline in the long term, decreasing from a high of 4.2 million tonnes in 2005 to 3.8 million tonnes in 2007 (or 14.2 percent of total aquafeeds), and expected to decrease further to 3.7 million tonnes by 2020 (or 5.2 percent of total aquafeeds). The reason for this is due to decreased fishmeal and fish oil supplies resulting from tighter quota setting and more controls on currently unregulated fishing, and the increased use of more cost-effective dietary fishmeal replacers. The use of fish oil by the aquaculture sector will probably remain at around the 2007 level (0.82 million tonnes or 3.0 percent of total feeds), and increased usage will shift from salmonids to marine finfish and crustaceans, due to the current absence of cost-effective alternative lipid sources rich in long-chain polyunsaturated fatty acids. Increasing volumes of fishmeal and fish oil are likely to come from fisheries by-products, extracted from both wild capture and farmed fish. Currently estimates have been made that around 25 percent of fishmeal production in 2008 came from by-products, and this will continue to grow as it becomes increasingly viable to process this material.

It is estimated that the total usage of terrestrial animal by-product meals and oils within compound aquafeeds ranges between 0.15 and 0.30 million tonnes or less than 1 percent of total global compound aquafeed production – clearly there is considerable room for increased usage. In addition to meat meal or to a lesser extent meat and bone meal, ingredients such as blood meal, poultry by-product meal and poultry oil have all been very effective in feeds for a number of aquatic species.

Soybean meal is currently the commonest source of plant proteins used in compound aquafeeds, with feeds for herbivorous and omnivorous fish species and crustaceans usually containing from 15 to 30 percent soybean meal, with a mean of 25 percent in 2008. In global usage terms and based on a total compound aquafeed production of 27.1 million tonnes in 2007, it is estimated that the aquaculture feed sector consumed about 6.8 million tonnes of soybean meal (25.1 percent of total compound aquafeeds by weight). Other plant proteins that are being increasingly used include corn products, pulses, oilseed meals) and protein from other cereal products.

Alternative lipid sources to fish oil are being used in greater amounts. Key alternatives include vegetable oils, preferably those with high omega-3 contents and poultry oil. The use of oil from farmed fish offal is also a potential omega-3 source for other farmed fish. The

production of marine microalgae or bacteria with very high contents of highly unsaturated fatty acids is currently expensive for use in most aquaculture feeds but as production methods become more cost-efficient, the situation is likely to change.

Prices for food and feed ingredients have been increasing and are likely to continue to increase due to increasing demands from the increasing population, diversion of some grains for use in biofuels, increasing costs of production and transport, and changes in global trade. The focus on carbohydrate-rich fractions for production of biofuels may indeed provide an opportunity to use protein fractions for feed ingredients.

Although the current discussion about the use of marine products as aquafeed ingredients focuses on fishmeal and fish oil resources, the sustainability of the aquaculture sector is more likely to be linked with the sustained supply of terrestrial animal and plant proteins, oils and carbohydrate sources for aquafeeds, particularly so because a significant proportion of aquaculture production is of non-carnivorous species. Therefore, aquaculture producing countries should place more emphasis on maximising the use of locally available feed-grade ingredient sources and move away from the use of potentially food-grade feed resources.

Expert Panel Presentation II.1

Improving Aquaculture Governance: What is the Status and Who is Responsible for What?

LEAD PANELLIST: NATHANAEL HISHAMUNDA

PANEL MEMBERS: IMTIAZ AHMAD, PEDRO BUENO, SLOANS CHIMATIRO, GEOFF J. GOOLEY, BLAISE KUEMPLANGAN, WILSON MWANJA, DAVID PERCY, NEIL RIDLER, BEN SATIA

Hishamunda, N., Ahmad, I., Bueno, P., Chimatiro, S., Gooley, G.J., Kuemlangan, B., Mwanja, W., Percy, D., Ridler, N., Satia, B. and Wijkstrom, U. 2010. Expert Panel Presentation II.1. Improving aquaculture governance: what is the status and who is responsible for what? Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

There is a consensus that modern aquaculture has a business orientation, similar to any small or medium-sized enterprise. For resources to be invested, there must be an enabling economic environment and secure property rights. However, there must also be controls or incentives to curb short-sighted business behaviour that damages the ecology or society. This requires that aquaculture not only be profitable but also environmentally neutral, technically feasible and socially acceptable. Governance plays an important role in achieving this goal.

This paper examines aquaculture governance from a global perspective, looking at its current status and the role of governments in administering and regulating aquaculture, including licence procedures, possible strategies and policy instruments. It also looks at the role and responsibilities of other stakeholders, such as industry, non-governmental organisations and communities.

Over the past decade, considerable progress has been made in addressing aquaculture governance issues. For example, many governments worldwide utilise the FAO Code of Conduct for Responsible Fisheries (CCRF), particularly its Article 9. They also use the FAO published guidelines for reducing administrative burdens and for improving planning and policy development in aquaculture, and have defined adequate national aquaculture development laws, policies, strategies and plans. Moreover, individual countries have used “Best Management Practices” and manuals on farming techniques that have been promoted by industry organisations and development agencies. The aim is to ensure an orderly and sustainable sector development.

However, aquaculture governance remains an issue in many countries. Some of its manifestations include conflicts over marine sites, disease outbreaks that could have been prevented, a widespread public mistrust of aquaculture in certain countries, inability of small-scale producers to meet foreign consumers’ quality standard requirements and inadequate development of the sector in certain jurisdictions despite favourable demand and supply conditions.

There are other key observations that emerge from this global perspective of aquaculture governance. Firstly, the importance of governance cannot be over-stated. It is as critical to successful aquaculture as feed, seed, capital and technology. Without good governance aquaculture operations will not appear or will not last. Markets and inputs may exist, but unless there are individuals willing to spend time and money, and face the risks, aquaculture operations will not be durable.

Secondly, private-sector entrepreneurs (farmers) are the drivers behind durable aquaculture. Their operations may be capital-intensive or low-input intensity but their motivation is risk-adjusted net income. This has been known for a long time in agriculture. Hence, secure property rights with the exclusive right to the proceeds, and protection from arbitrary confiscation of farms are among the minimum conditions for private sector investment. Such property rights are among the factors that underpin an “enabling environment”. Other factors include economic and political stability, the rule of law, low levels of corruption, and effectiveness and efficiency of government activities. If they are in place and markets and inputs exist, entrepreneurs are more likely to invest in aquaculture.

Thirdly, the behaviour of entrepreneurs must be circumscribed. This can be done by economic incentives, peer pressure or regulations. The ideal would be for self-regulation, because then entrepreneurs’ sense of corporate governance would value all stakeholders, including future generations. Unfortunately, experience has demonstrated that many

entrepreneurs will ignore negative externalities in their pursuit of short-term profits. Hence, their behaviour must be modified so their interests are reconciled with those of the broader society.

Finally, because the goal of aquaculture governance is to maintain a sustainable industry, the three observations above must be acknowledged and implemented by policy-makers. Not only must an enabling environment permit entrepreneurs to create a profitable and competitive industry, negative externalities mitigated if not avoided altogether and social licence encouraged by accountability and transparency, but also policy-makers must learn from best practices elsewhere and implement them. Mariculture governance will require particular attention.

Expert Panel Presentation II.2

Aquaculture and Socio-Economic Growth and Development: Enabling Policies, Legal Framework and Partnership for Improved Benefits

LEAD PANELLIST: PINGSUNG LEUNG

PANEL MEMBER: NATHANAEL HISHAMUNDA

Leung, P. and Hishamunda, N., 2010. Expert Panel Presentation II.2. Aquaculture and socio-economic growth and development: enabling policies, legal framework and partnership for improved benefit. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The *Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* recognised that aquaculture has great contribution to people's livelihoods, food security, poverty alleviation, income generation, employment and trade; and the potential of aquaculture's contribution has not yet been fully realised across all continents. It also recognised that aquaculture's potential to contribute to human development and social empowerment cannot be fully realised without consistent, responsible policies and goals, effective institutional arrangements and regulatory frameworks, and improved co-operation among stakeholders at the national, regional and inter-regional levels. It suggested that the aquaculture sector should continue to be developed towards its full potential of contributing towards sustainable livelihoods, human development and social well-being.

Over the past decade, aquaculture expansion has been driven mainly by the private sector's motive for profits. Through innovations in technology and organisation; intensification in operations; and diversification in products, species and culture systems, aquaculture continues growing in the new millennium towards a matured and global industry, accounting

for half of the world human seafood consumption and with half of its products traded across borders. While the sector is still mainly motivated by and promoted for its economic benefits, increasing attention has been paid to aquaculture's environmental and social responsibilities. Learning from past experience of runaway yet unsustainable aquaculture growth, many governments have used regulations and public policies to establish clear guidelines for resource utilisation and to promote sustainable practices in aquaculture operations. Policies and regulations have also been used to address public concerns over the potential negative environmental and social impacts of aquaculture; certification schemes have been initiated to address consumer's health concerns. As a result, fish farmers have become increasingly aware of the importance of long-term sustainability and more willing to adopt codes of conduct, best management practices, farmers' groups, and other self-discipline mechanisms. Globally, the main theme of aquaculture development in the first decade of the new millennium seems to be sustainable economic growth, environmental stewardship and social responsibility.

Even though globally the impressive aquaculture development of the last decade has led to the recognition of the sector as more than just a branch of fisheries, institutional arrangements for sustainable aquaculture development have only made baby steps and have many aspects to improve. In most countries there are still lack of aquaculture-specific laws and regulations; the sector has to deal with diverse regulations designed by different agencies for diverse sectors touching upon aquaculture but often without due consideration of the aquaculture sector. Even with laws and regulations specifically targeting aquaculture, the lack of institutional and human capacity for their implementation may render them ineffective. While certification schemes have helped facilitate environmentally and socially responsible behaviours, their proliferation has often caused confusion, increased costs of compliance, and in some cases, fostered cynicism that these schemes are no more than marketing trickeries for higher profit margins. Despite increasing awareness, knowledge and technical constraints tend to hinder farmers' attempts to fulfil their environmental and social responsibilities.

An economically efficient, environmentally friendly and socially responsible aquaculture sector will benefit everyone because of its associated invaluable environmental and social amenities. However, this win-win situation is difficult to achieve because of diverse hindrances. Externalities (people may not know or care about the impacts of their behaviours on others), moral hazard (people may think their individual irresponsible behaviours do not matter much as long as others are environmentally and socially responsible), adverse selection (profit-driven people may want to free-ride those who are environmentally and socially responsible) and asymmetric information (even when all the people are willing to simultaneously internalise their externalities for mutual benefits, it will not happen because of lack of communication and trust) are some of these barriers. As is the case in many countries, various institutions can be set up to neutralise these obstacles. Laws and regulations are only one of them and may not be the most efficient or effective one. In any case, efficient and effective institutional arrangements for sustainable aquaculture development would, at minimum, require understanding of the socio-economic

impacts of the sector, and the willingness of the governing authorities to set up policies, laws and regulations; enforce environment stewardship and facilitate equitable development, as well as effective partnership among stakeholders for decision-making, cost and benefit sharing, and conflict resolution.

This paper builds on countries' recent experiences to review the role of aquaculture in countries' socio-economic growth and development, and discusses how institutional arrangements (including policies, laws, regulations and effective partnership among stakeholders) can lead to aquaculture's enhanced net benefits to society. Aquaculture growth has recently been slowing down, and the sector is facing various resource, environmental, economic, knowledge and institutional constraints. Fortunately, as population growth, economic expansion and increasing preference for healthy food are expected to continue sustaining the demand for aquaculture products, there would be a relatively benign environment to foster environmentally and socially responsible behaviours in this highly profit-driven and lucrative sector.

Expert Panel Presentation II.3

Investment, Insurance and Risk Management for Aquaculture Development

LEAD PANELLIST: CLEMENT TISDELL

PANEL MEMBERS: BENEDICTO BAYAU, TERRY HANSON, NATHANAEL HISHAMUNDA, CURTIS JOLLY, GUNMAR KNAPP, CAREL LIGEON, TIPPARAT PONGTHANAPANICH, EVA ROTH, PADDY SECRETAN, SUSAN SIAR, DIEGO VALDERRAMA, RAYMON VAN ANROOY, MAROTI UPARE, MARK VOS

Tisdell, C., Bayaua, B., Hanson, T., Hishamunda, N., Jolly, C., Knapp, G., Ligeon, Pongthanapanich, T., C., Roth, E., Secretan, P., Siar, S., Valderrama, D., Van Anrooy, R., Upare, M., and Vos, M. Expert Panel Presentation II.3. Investment, insurance and risk management for aquaculture development. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The *Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* stressed that adequate investment in aquaculture is essential for its future development. It identifies several constraints on this investment and makes recommendations for addressing the issues involved. For example, it recognises the risk and uncertainty associated with returns from investment in aquaculture to be an important constraint on aquaculture investment. This is particularly so because insurance markets only provide very limited coverage for aquaculturists.

Since 2000, research has been undertaken by the FAO to address many of the issues raised in the Bangkok Declaration. This process has not been straightforward because most of the objectives for investment in aquaculture set out in this declaration are indicative rather than operational. In addition, some constraints that are not mentioned in the Bangkok Declaration of 2000 have started to seriously impede aquaculture development. Economic growth generally and the expansion of aquaculture itself have resulted in increased scarcity of resources vital for the growth of aquaculture. For example, water has become scarcer, available new sites for aquaculture are becoming more difficult to obtain, and environmental and ecological problems of consequence for aquaculture have magnified. Because of the latter aspect, greater regulation of economic activity, including aquaculture production is occurring.

These growing problems appear to have resulted in a decline in the rate of growth of aquaculture production and are associated with a slight decline in the global per capita availability of fish. This poses new challenges for investment in aquaculture and its future growth. The future development of aquaculture is likely to depend more on the intensification of aquaculture production and less on its extension than in the past. Furthermore, the future development of aquaculture is expected to become more dependent on advances in science and technology than in the past and therefore, investment in science and technology and its application to aquaculture will be of growing importance.

Apart from tightening resource constraints on the development of aquaculture, high levels of exposure to risk and uncertainty in aquaculture continue to restrict investment in aquaculture and stunt its development. Attention is therefore given in this paper to identifying the factors that contribute to risk and uncertainty in aquaculture and methods of specifying the risk and uncertainty involved. The latter should be done by taking into account consequences of these methods for decision-making by aquafarmers. Alternative methods of managing and coping with risk and aquaculture are outlined and particular attention is given to insurance of assets as a way to cope with risk in aquaculture. Ways of extending the availability of insurance cover for aquafarmers are outlined.

It is found that there is limited practical scope for the extension of insurance markets in aquaculture, although with economic development, it is likely that extension will occur naturally. This means that most aquafarmers have to rely on other means to manage and cope with risk and uncertainty. There is scope for further exploration of their managerial alternatives for coping with risk and uncertainty in aquaculture.

Expert Panel Presentation III.1

Promoting Responsible Use and Conservation of Aquatic Biodiversity for Sustainable Aquaculture Development

LEAD PANELLIST: JOHN BENZIE

PANEL MEMBERS: DEVIN BARTLEY, RANDALL BRUMMETT, BRIAN DAVY, MATTHIAS HALWART, G. HULATA, ZHU JIAN, GRAHAM MAIR, UTHAIRAT NA-NAKORN, THUY T.T. NGUYEN, R.S.V. PULLIN, IGOR SOLAR

Benzie, J., Bartley, D., Brummett, R., Davy, B., Halwart, M., Hulata, G., Jian, Z., Mair, G., Na-Nakorn, U., Nguyen, T.T.T., Pullin, R.S.V., and Solar, I. Expert Panel Presentation III.1. Promoting responsible use and conservation of aquatic biodiversity for sustainable aquaculture development. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The projected increase in the world's human population over the next 50 years is thought to require an increase in food production of 1.5–2.0 times that currently achieved by food production systems. Aquaculture, the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants, now supplies half the total world production of these foods (FAO, (2009) The State of the Worlds Fisheries 2008). Aquaculture production has increased by about 8 percent per year over the past 20 years and continues to be the fastest-growing food production sector. The increasing demand for seafood in the face of static or declining production by fisheries can only be met by increasing aquaculture production. However, the ability of aquaculture to achieve this will depend on accessing new areas of production and increased efficiency of production from existing areas.

Like agriculture, where most of the land suitable for cultivation is already being used, suitable aquaculture sites are limited. Recognition of the value of natural biodiversity, documentation of its loss over the recent past, the increasing vulnerability of the remaining fragments and recognition of the utility of natural habitats for the delivery of vital ecosystem services also reduce the ability and/or advisability of prioritising many places for food production. There is scope for increasing production by accessing new regions for fish farming, such as the open sea, although this will require the development of innovative engineering technologies. Similarly, increased production could be achieved by bringing more species into culture. However, more production from existing areas has the greatest immediate scope for improved production, through application of more intensive farming practices, the application of genetic improvement to a greater range of aquaculture species and a more rapid application of the newest and more powerful methods of genetic improvement to aquaculture species.

Aquaculture is a sector that is likely to benefit greatly from the application of appropriate genetic and reproduction biotechnologies to increase food production, but the application of established genetic improvement methods in aquaculture is much less than in agriculture. Reasons for this include the diversity of species in aquaculture at present (over 230), lack of knowledge of the biology of many of these species and the cost of technology development. These constraints explain in part why biotechnologies are only now emerging as useful tools for increasing the productivity and sustainability of this sector. Knowledge of the aquatic environment and its diversity and genetic resources are also much less than that of the terrestrial sphere. Recent improved understanding of the genetic variety of wild populations, the rapid differentiation of stocks domesticated from these, and the high mobility of many aquatic species has led to concerns over the potential deleterious interaction of wild and domesticated stocks. Given this context, the aquaculture sector will need to rationalise the number of species or species groups on which genetic improvement will focus. Only a handful of species has paid dividends through increased productivity from the application of the genetic improvement to date. The sector needs to broaden and accelerate this front, but with an explicit understanding of what species/species groups will be worked on and how this effort could be rationalised through international effort(s).

The world's wealth of aquatic biodiversity at the genetic, species and ecosystem levels provides great potential for the aquaculture sector to enhance its contribution to food security and meet future challenges in feeding a growing human population. To realise and explore this potential, issues of access and use of aquatic genetic resources for aquaculture need to be considered. Different to the plant and terrestrial animal-farming sector, aquaculture still depends largely on the natural genetic resources as an important source for broodstock for many species. However, with increased fragmentation and habitat destruction and in the context of climate change, these important resources are under threat. A global approach to responsible use and conservation, effective policies and plans, better information including characterisation of aquatic genetic resources at different levels, and wider use of genetic applications in aquaculture are identified as some of the important elements needed to improve management of aquatic genetic resources. The panel of experts will assess salient issues regarding the status and future trends towards the sustainable use, conservation and exchange of aquatic genetic biodiversity.

Expert Panel Presentation III.2

Ecosystem Approach to Aquaculture and Interactions Between Fisheries and Aquaculture

LEAD PANELLIST: DORIS SOTO

PANEL MEMBERS: TIM DEMPSTER, SENA DE SILVA, ALEJANDRO FLORES, YANNIS KARAKASSIS, GUNNAR KNAPP, JAVIER MARTINEZ, WEIMIN MIAO, YVONE SADOVY, EVA THORSTAD, PATRICK WHITE, RONALD WIEFELS

Soto, D., Dempster, T., De Silva, S., Flores, A., Karakassis, Y., Knapp, G., Martinez, J., Miao, W., Sadovy, Y., Thorstad, E. White, P., and Wiefels, R. Expert Panel Presentation III.2. Ecosystem approach to aquaculture and interactions between fisheries and aquaculture. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The Ecosystem Approach to Aquaculture (EAA) emphasises inter-sectoral complementarity by taking account of interactions between the activities within ecologically meaningful boundaries and multiple services of ecosystems.

The main objective of this review is to understand the status of aquaculture-fisheries interactions associated with the biological, technological, social, economic, environmental, policy, legal and other aspects of aquaculture development. It goes on to analyse how the interactions are or could be addressed under the EAA. It covers aspects of scoping, prioritising, management tools and plans (minimising negative effects and optimising positive ones) within the context of the elements of ecosystem resilience, social and economic issues and the integration of aquaculture with other sectors. Relevant spatial scales are also considered, particularly the watershed and related marine waterbody scale and potential transboundary issues.

Aquaculture and fisheries are subsectoral activities that often depend on the same resources and share the same ecosystem boundaries. Effective implementation of the Ecosystem Approach to Fisheries/Aquaculture will require a good understanding of their interactions and mutual impacts. The interactions reviewed here are the most commonly known and are often referred to as issues.

Aquaculture or culture-based fisheries (stock enhancement) has positive impacts including: establishment of new/additional fish resources for capture and recreational fisheries, provision of livelihoods, and conservation and improvement of certain fisheries through enhancement of over-fished stocks. Potential negative impacts include: pressure on natural fishery resources due to competition for food/habitat, predation and potential alteration of

genetic diversity of natural stocks. However, well-managed culture-based fisheries can provide required biomass while minimising environmental effects, since no external feeding is needed. Aquaculture escapees could have positive and negative impacts similar to those described for stock enhancement, although as an unplanned event they are more likely to have negative effects on fisheries. An additional concern is the transmission of diseases to wild populations, with possible impacts on fisheries.

Within capture-based aquaculture, positive effects can include provision of livelihood for fishers as provider of seed, broodstock and feed; better priced products and greater income derived from final grow-out products. Potential negative effects include impacts on wild populations and fisheries through the capture of target larvae/juveniles and by-catch impacts on other fisheries,

The use of fisheries as feed to aquaculture in the form of direct feed (e.g. trash fish/ low-value fish) and feed ingredients (fishmeal and fish oil) could negatively affect the resource for direct fishery intended for consumption. On the other hand, positive impacts include the provision of livelihoods for fishers and of jobs and income (fishmeal fisheries).

Aquaculture systems and processes could disturb natural habitats and breeding areas, affecting fisheries (e.g. cutting of mangroves for shrimp culture, affecting sea grasses, reproductive habitats and causing fish mortality due to eutrophication from nutrient overload). Positive effects include increased fishery productivity through additional nutrients, especially in more oligotrophic areas.

The social impacts from aquaculture on fisheries communities include livelihood options for local traditional fishers and families through direct engagement or providing inputs (seed and feed). Negative effects include reduction in capture fisheries and limited access to the fishery due to aquaculture activities. There are also post-harvest and market impacts, including positive effects such as improved market access and improved trade and safety aspects for fishery products due to aquaculture outputs. There are also negative effects such as market competition and price decrease due to increased product availability. Obviously, the most important positive impacts of fisheries on aquaculture are related to seeds and feeds, while the availability of fishery processing wastes and markets can be considered as facilitating factors for aquaculture.

In order to ensure close integration between aquaculture and fisheries and the optimal management of multiple use of the same aquatic resources, the full set of ecosystem interactions needs to be considered. This includes ecological functions and the services they provide, as well as clear understanding of the economic, social and cultural values that people attach to these services. One such example is stock enhancement, which has been successfully used to mitigate nutrient overloading from aquaculture practices, thereby reducing fish kills (e.g. cultured stocks in cages) and in the same vein, increasing the output from capture fisheries in the open waters, thereby increasing fisher incomes and foodfish

production, and resulting in an overall reduction in eutrophication and nutrient levels in the waterbodies, returning them to an almost original ecological status.

Within the EAA, the identification of aquaculture/fisheries interactions as relevant issues is a first step. This must be done with the relevant stakeholders, including aquaculture and fisheries players. The root of the issues must be recognised and operational objectives must be agreed upon within the existing policy frameworks. Often, however, it is necessary to review such policies and also the current regulations, this being necessary to identify the proper management measures (often affecting both sectors in a coordinated way) that must be recognised and agreed upon by the relevant fisheries and aquaculture stakeholders (including civil society and government). Concepts and indicators of environmental carrying capacity within ecosystem boundaries and a broader social and economic appraisal for both aquaculture and fisheries are required. Regular monitoring is required to assess the impacts and provide feed back into management and control. Management measures should also look for improved complementarity between the sectors, considering the need for balancing positive and negative effects and also inter-generational impacts (i.e. what is left for future generations). Often, institutional changes are required to address the issues of both fisheries and aquaculture, perhaps more often effectively implemented through a co-management strategy.

Expert Panel Presentation III.3

Improving Biosecurity: A Necessity for Aquaculture Sustainability

LEAD PANELLIST: MIKE HINE

PANEL MEMBERS: SANDRA ADAMS, RICHARD ARTHUR, DEVIN BARTLEY, MELBA G. BONDAD-REANTASO, CRISTINA CHÁVEZ, JESPER CLAUSEN, TIM FLEGEL, ROAR GUDDING, ERIC HALLERMAN, CHAD HEWITT, IDDYA KARUNASAGAR, C.V. MOHAN, RAMESH PERERA, PETER SMITH, ROHANA SUBASINGHE, ROBIN WARDLE

Hine, M., Adams, S., Arthur, R., Bartley, D., Bondad-Reantaso, M.G., Chávez, C., Clausen, J., Flegel, T., Gudding, R., Hallerman, E., Hewitt, C., Karunasagar, I., Mohan, C.V., Perera, R., Smith, P., Subasinghe, R., Wardle, R. 2010. Expert Panel Presentation III.3. Improving biosecurity: a necessity for aquaculture sustainability. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

More than 200 species are produced in aquaculture worldwide; some 25 of these are of high value and traded globally. A successful harvest can be very profitable, and this has spurred the expansion of aquaculture production in both area and geographical range. Species

movement for farming, when done in a haphazard manner, can be one of the many sources of biological threats to the well-being of farmed aquatic animals, as well as that of humans and ecosystems. As aquaculture intensifies and diversifies, the biological hazards and risks to farmed animals, people and ecosystems also increase in number and diversity, with serious consequences. Some of these are infectious diseases, animal pests, public health concerns on residues and resistance of antimicrobial agents, zoonoses, invasive alien species, release of genetically modified organisms (GMOs) and biosecurity risks posed by climate change. The growing number, complexity and seriousness of these risks have driven the development of the concept of biosecurity and its increasing application in many food-producing sectors, including agriculture. FAO defines biosecurity as a strategic and integrated approach that encompasses the policy and regulatory frameworks that analyse and manage risks in the sectors of food safety, animal and plant life and health, including associated environmental risk. An integrated strategy to manage biosecurity, business, environmental and social risks will better promote sustainable growth of the sector.

Transboundary aquatic animal diseases (TAADs) may occur due to illegal introductions and transfers of live animals, lack of controls on movements, inability to detect potential pathogens in apparently healthy animals and the ornamental fish trade, which is now recognised as an important pathway for disease dissemination. Many marine invasive pests are now recognised, the majority of which are linked to a transport vector, particularly shipping, with some being associated with hull fouling and ballast water. Other movements may be due to fisheries stocking, live seafood trade and movement of species for aquaculture, bio-control and scientific research. Food safety concerns in aquaculture include antimicrobial and chemical residues and live human parasites such as food-borne trematodes. While vaccination may reduce the use of antimicrobial agents, some vaccines with adjuvants may impact on animal welfare. Although the use of antimicrobial agents may result in resistance among targeted bacteria, there is so far no evidence of effects on human health. Veterinary medicinal products are being developed to overcome residue problems and minimise food safety risks. While GMOs may be beneficial with regard to increased production, disease and freeze resistance, and reproductive sterility, large-scale escape from confinement may cause genetic replacement of local stocks.

Many of these issues, however, are being addressed at varying degrees and different levels. For example, national strategies and policy frameworks to control TAADs have been developed in Australia, North America and Asia and are being formulated in Latin America and the Caribbean (LAC), as well as southern Africa. Some of the important elements of such frameworks include, for example, disease diagnosis, quarantine considerations, surveillance and reporting, adoption and implementation of OIE standards and other voluntary guidelines, and emergency preparedness. These are supported by educational and extension programmes, development of resource materials, establishment of reference and competent laboratories, and provision of technical assistance at the farm/local/national/regional levels. New developments in diagnostic techniques, such as serological detection of koi carp herpes virus, lateral flow technology for infectious salmon anaemia and white

spot disease of shrimp, and molecular genomics all improve diagnostic capacities, thus reducing the risk of TAADs.

At the heart of the modern approaches to biosecurity is the application of risk analysis. It offers an effective management tool where pragmatic decisions can be made that provide a balance between competing environmental and socio-economic interests, despite limited information. This tool, however, needs research, databases and other vital sources of information and knowledge so that it can effectively support biosecurity assessments, surveillance, diagnostics, early warning and contingency planning.

Sections 3.11 (managing aquatic animal health), 3.13 (applying genetics to aquaculture), 3.14 (applying biotechnology) and 3.15 (improving food quality and safety) of the 2000 Bangkok Declaration are all relevant to biosecurity. Traditionally such concerns have been addressed using the sectoral approach to biosecurity, and what is lacking is a holistic systems approach to aquatic animal health management and biosecurity. Also missing from the declaration are specific references to invasive pests, particularly in relation to ships' ballast water and hull fouling, aquatic plants and the global trade in ornamental animals, now seen as a major loop-hole in attempts to control TAADs.

Effective, coordinated and proactive biosecurity systems are the product of science-based knowledge and practices used within effective regulatory frameworks that are backed by sufficient resources for enforcement. As aquaculture becomes more intensive, new diseases and other problems are likely to emerge, and old diseases will appear in new locations. Aquaculture biosecurity will continue to operate at three levels: a) internationally, as recognised in the Bangkok Declaration; b) regionally, as seen through various regional activities; and c) on a small scale where variables (environment, species cultured, funding, training, economics) differ within countries in a region. A crucial consideration is how to deal with "unknowns". The need to forge an effective regional and international cooperation to pool resources and share expertise and information will be essential. At the global, regional or national levels, the institutions mandated to ensure biosecurity would be served well by putting emergency preparedness with advanced financial planning as their core function.

This session will take a broad spectrum approach on as many aspects of biosecurity as possible and will identify successes and failures, issues of importance to regions and the role of biosecurity in the sustainable increase in aquaculture production. Hopefully, it will result in linkages between groups to tackle or solve specific problems. Ideas will be canvassed on what needs to be achieved over the next ten years. There are several likely trends. New technologies will permit accurate and rapid pond-side diagnosis of disease and simultaneous testing for multiple pathogens that would greatly benefit the detection of multiple asymptomatic viral infections in shrimp and permit tighter controls on movement of these infections. Veterinary pharmaceutical companies will work closely with the aquaculture industries to provide more efficacious, safe, rapid and cost-effective treatments designed specifically for aquaculture. Animal welfare is likely to become an issue in aquaculture, particularly with increased intensive farming. Just as there has been impressive capacity

building in biosecurity in Asian aquaculture and its nascent development in LAC and Africa, these processes must continue to improve and spread to other continents as aquaculture develops. We will also see more interaction between aquaculture fish health specialists and veterinary practitioners, supported by appropriate certification schemes that will enable provision of effective biosecurity services and guidance to the sector. Climate change scenarios (e.g. sea level rise, increased incidence of storm surges and land-based run-offs, extreme weather events, etc.) that may affect biosecurity (e.g. by increasing range of pests and pathogens, intensities of their occurrence and vulnerabilities of farmed animals to diseases) will also be significant and will need to be addressed.

Expert Panel Presentation IV.1

Facilitating Market Access for Producers: Addressing Market Access Requirements, Evolving Consumer Needs and Trends in Product Development and Distribution

LEAD PANELLIST: JONATHAN BANKS

PANEL MEMBERS: JIM ANDERSON, NGUYEN DZUNG, JOHN FILOSE, NICOLE FRANZ, DOMINIQUE GAUTIER, ATLE GUTTORMSEN, AUDUN LEM, ROY PALMER, FERIT RAD, THOMAS REARDON, MELANIE SIGGS, NOBUYUKI YAGI, JIMMY YOUNG

Banks, J., Anderson, J., Dzung, N., Filose, J., Franz, N., Gautier, D., Guttormsen, A., Lem, A., Palmer, R., Rad, F., Reardon, T., Siggs, M., Yagi, N., Young, J., 2010. Expert Panel Presentation IV.1. Facilitating market access for producers: addressing market access requirements, evolving consumer needs, and trends in product development and distribution. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The market for fish and fisheries products is a globalised market with close to 40 percent of total production (capture fisheries + aquaculture) entering international trade. Not only is this share higher than for other food or agricultural products, so is the role of developing-country exporters in total exports (around 50 percent), underscoring the sector's importance in contributing to local, regional and international food security in general and as a generator of economic activity, employment and of net export revenue to the developing world in particular.

Total world fish production has grown to 143 million tonnes, of which 53 million tonnes come from aquaculture. For 2009 the contribution of aquaculture to the supply of fish and fishery products for human consumption (excluding fishmeal) is estimated to have reached 45 percent of the total. The rise of aquaculture in production and trade is having a significant impact on prices, product development, distribution and consumption patterns. The exact

share of aquaculture in trade remains unknown, given that international statistics do not distinguish between the two origins.

There are large regional differences in fish consumption per capita, but also within regions. In general, urbanisation and the growth of modern distribution channels for food have increased the potential availability of fish to most of the world's consumers. Economic and cultural factors continue to influence strongly the level of fish consumption.

International trade in fish and fishery products has grown strongly over the last decades. Despite the recent contraction in consumer spending, the long-term trend for fish trade remains positive, with a rising share of both developed and developing country production entering international markets. The potential for increased demand offers significant opportunities to aquaculture producers but also challenges their ability to find innovative ways to supply markets with products aimed at satisfying consumer needs. This could include new technology to provide more targeted portion sizes, taste varieties as well as innovative packaging and communication strategies. Post-harvest losses could also be reduced in the future.

Fish imports are mostly by developed countries, now responsible for 77 percent of the total import value (2008). This dominance presents a challenge to exporters from developing countries in particular, as adhering to market access requirements becomes a prerequisite for entering international markets. In addition the changing nature of these market access requirements, including the emergence of private and voluntary standards and requests for certification and labels for various purposes, put additional pressure on producers, processors and exporters, without necessarily offering higher prices to offset the additional costs incurred. Of note is also the rise in consumption and imports in emerging economies as their purchasing power increase and middle-class consumers adopt international food habits and purchasing practices.

Certification schemes for both wild and farmed products are gaining market share in many developed country markets. However, consumer confusion is also increasing given the often diverging claims represented by many of the schemes.

In general, the long-term rise in aggregate trade values and volumes for all commodities reflects the increasing globalisation of the fisheries value chain. Production and processing is outsourced to Asia and, to a lesser degree, Central and Eastern Europe, North Africa and Central America. This includes the rising share of aquaculture production in developing countries. Outsourcing of processing takes place both at the regional and global levels, depending on the product form, labour costs and transportation time. In general, labour cost differences play a much larger role than transportation issues. At the same time, the growth of global distribution channels through large retailers has furthered this development.

The newly developed FAO Fish Price Index shows quite separate price developments over time for captured fisheries and for aquaculture; the former increased significantly

in the 2002–2008 period whereas aquaculture prices, despite some firming during the same period, are indeed lower today than they were 10 years ago. The main reason is probably related to the cost of input factors; capture fisheries are frequently energy and capital intensive, whereas aquaculture has benefited to a larger degree from technological improvements, increased yields in production, and improved logistics and distribution systems. Thanks to its growing volumes, aquaculture producers also increasingly benefit from economies of scale.

The role of the retail sector within the distribution channel continues to be debated, especially its negotiating power on prices. Aquaculture products, however, have certain advantages over wild products that increase their share of supermarket sales. In the future markets are more likely to distinguish between the two origins. Consumers are increasingly concerned about sustainability issues, especially overfishing. Global warming is also a growing concern. Air transportation of food is increasingly questioned. Health and well-being are other factors influencing consumption decisions; this explains in part the rise of the organic food sector. The principal purchasing parameters among consumers remain, however, price and food safety. The perceived benefit of fish consumption is strong in consumers' minds.

International fish trade is governed by the rules of the World Trade Organization (WTO), which now practically includes all major fish-producing, importing and exporting countries. Membership in the organisation is a prerequisite for having access to its Dispute Settlement Mechanism, which increasingly has been used to solve disputes involving both wild and farmed fisheries products.

In a not too distant future, aquaculture's share of total supply for human consumption will rise to somewhere between 60 and 70 percent. This will have a profound impact on the sector's ability to shape world markets in areas of pricing, product development, distribution and consumption; but it will also challenge the sector's ability to respond successfully to evolving consumer needs. The potential for growth and economic success is evident; so are the many challenges presented to the world's aquaculture producers.

Expert Panel Presentation IV.2

Consumer Assurance: Market-Based Quality Schemes, Certification and Traceability, Ecolabelling, Retailer Specifications

LEAD PANELLIST: LAHSEN ABABOUC

PANEL MEMBERS: PATRICK BLOW, FLAVIO CORSIN, JON HARMAN, ANA MARIA ECHEVARRIA, GREGORY J. MORROW

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Fish and fishery products are the most internationally traded food commodity. Over one third (live weight equivalent) of the total yearly production has been entering international trade during the last decades. Aquaculture production, especially of shrimp, salmon, tilapia, catfish and bivalves, contributes significantly to this trade. About half of global fish trade in value originates in developing countries, whereas around 75 percent is destined to three major markets, the European Union (EU), Japan and the United States of America. These three markets dominate fish trade both in terms of prices and market access requirements.

In aquaculture, this increase in international fish trade has led to the emergence of major issues related to i) environmental impacts of aquaculture as a result of its increasing role for fish food supply, ii) consumer protection and food safety requirements, iii) animal health and animal welfare, iv) social responsibility and v) traceability and consumer information along the aquaculture supply chain

Consumer protection and food safety remain a major concern, particularly in light of the increasing complexity of supply chains and the greater awareness and demand of consumers for safe and high quality food, exacerbated by the recurrent food safety scares since the 1990s. Aquaculture is no exception, and aquaculture products have been subject to close scrutiny for their safeness for consumption. For example, the EU alert system for food and feed indicated that fish and fishery products have often been responsible for a large proportion (sometimes the largest – up to 25 percent), of food safety and quality alerts during the period 2000–2005. Of these, aquaculture products were involved in 28 to 63 percent of alert cases, mainly because of the presence of high residues of veterinary drugs, unauthorised chemicals and bacterial pathogens. Similar safety problems have been reported by the food control authorities of other major fish-importing countries.

In addition to food safety, concerns over environmental protection, social responsibility and animal health have been receiving increasing attention. Non-governmental organisations

(NGOs) have tapped into or driven these concerns and developed strategies to wield influence over consumers' purchasing decisions and especially over the procurement policies of major buyers and retailers. As the last link in the supply chain between producers and consumers, retailers aim at translating and transmitting these consumer demands by imposing private standards and certification back through the supply chain, especially on producers and processors, to reflect their increased responsibility towards consumers and to prevent any risk to their reputation. These developments have resulted in the proliferation of aquaculture standards and certification schemes designed to trace the origin of fish, its quality and its safety, and the environmental and/or social conditions prevailing during aquaculture production, processing and distribution of fish and feed. Small market niches are governed by specific standards such as "label rouge" in France, "Quality Mussels" in Ireland or Canada or "organic farmed fish" labels. Furthermore, some countries and producers' associations have established labels to certify implementation of best practices or codes of conduct.

As standards, certification schemes and claims proliferate, their value is being questioned. Producers and producing countries in particular question whether these private standards and certification schemes duplicate or complement government work, especially in relation to food safety and animal health. Likewise, consumers ask if private schemes really provide better protection for them and the environment and/or contribute to social equity.

This unprecedented development in market standards raises the following major issues:

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

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

complying with these standards may fall disproportionately on small suppliers, for whom the cost of achieving certifiable status is relatively higher.

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

The panel of experts will review current practices and future trends in market-based quality standards and certification schemes in aquaculture, including international initiatives to promote transparent market standards for improved safety, quality and sustainability in aquaculture.

Expert Panel Presentation IV.3

Organic Aquaculture - the Future of Expanding Niche Markets

LEAD PANELLIST: MARK PREIN

PANEL MEMBERS: MARCUS BALLAUF, STEFAN BERGLEITER, DEBORAH BRISTER, MATTHIAS HALWART, KRITSADA HONGRAT, JENS KAHLE, TOBIAS LASNER, AUDUN LEM, OMRE LEV, CATHERINE MORRISON, MARC NOLTING, ZIAD SHEHADEH, ANDREAS STAMER, ALEXANDRE A. WAINBERG

Prein, M., Ballauf, M., Bergleiter, S., Brister, D., Halwart, M., Hongrat, K., Kahle, J., Lasner, T., Lem, A., Lev, O., Morrison, C., Nolting, M., Shehadeh, Z., Stamer, A., Wainberg, A.A. 2010. Expert Panel Presentation IV.3. Organic aquaculture: the future of an expanding niche market. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

There is unprecedented growth in the demand for organic food and new areas of organic food production, such as fish, are proving increasingly popular. In reference to the *Codex Alimentarius*, organic aquaculture refers to the production processes and practices of ecological production management systems that promote and enhance biodiversity, biological cycles and [pond bottom] biological activity. It is based on minimal use of off-farm inputs and on holistic management practices that restore, maintain and enhance species diversity and ecological harmony. More generally, the primary goal of organic agriculture is to optimise the health and productivity of interdependent communities of soil life, plants, animals and people. However, details are often unclear to the consumer.

Today, several specific and relatively precise standards of organic aquaculture production (hatchery, feed, grow-out) and processing exist which aim at achieving optimal agro-ecosystems which are socially, ecologically and economically sustainable. Impartial organisations take part in the inspection and certification process to ensure that those production and processing standards are adhered to.

The total global production of organic aquaculture production increased by 950 percent from 5,000 tonnes/year in 2000 to 53,500 tonnes per year in 2009, produced by 240 certified organic aquaculture operations in 29 different countries. In China alone, 72 operations have received organic aquaculture certification. Based on data from 2008, the majority (25,000 tonnes/year) of organic aquaculture production is farmed in Europe, followed by Asia (19,000 tonnes/year) and Latin America (7,000 tonnes/year). By individual countries, China leads with 15,300 tonnes/year followed by the United Kingdom (9,900 tonnes/year) and Ecuador (5,800 tonnes/year).

The total market value was estimated at €230 million in 2009 (€1 = US\$1.217 approximately). The major markets for organic aquaculture products are European countries, led by Germany, the United Kingdom, France and Switzerland. Here features of an evolving market are observed, such as increasing sales volumes, growing competition in increasing numbers of new outlets and market channels, and increasing pressure to decrease prices. United States of America considered to have a large potential once regulations are passed by the US Department of Agriculture. Developing countries are showing gradual expansion of organic aquaculture markets, however these are characterised by high prices, low sales volumes, little or almost no competition and the need to invest in marketing and create consumer awareness of organic aquaculture products.

The number of species from organic aquaculture has increased from four species in 2000 to around 30 species in 2009, including at least 15 fish species, six crustacean species, at least one mollusc species, one holothurian, one turtle, and at least four species of microalgae. For some species of which conventional (i.e. non-organically certified) products are sold in large volumes, such as Atlantic salmon (*Salmo salar*) and striped catfish (*Pangasianodon hypophthalmus*), supply growth of organically produced products has reportedly not been keeping up with demand growth. By species, salmon had the highest production of 16,000 tonnes/year in 2008, followed by “shrimp” (combining *Litopenaeus vannamei* and *Penaeus monodon*) with 8,800 tonnes/year and common carp with 7 200 tonnes/year.

Around 80 different organic aquaculture standards exist, both public as well as private, of which those with the greatest number of certified farms are Naturland, AB France and Bio Suisse. Due to frequent compatibility among labels, farms may obtain certification according to more than one label, in order to access a greater variety of markets. However, the greater majority are certified according to one label only. As of 1 July 2010 the new EU organic aquaculture implementing rules will be applicable. These constitute a consensus “minimum” standard and other existing standards are stricter in their requirements. One of the issues

of debate is there is no limit to the percentage of fishmeal in feeds for coldwater species such as trout, Atlantic salmon and cod, whereas shrimp and pangasius have a permissible fishmeal limit of 10 percent in their organic feeds.

The most salient issue in organic aquaculture production is the existing bottleneck in supply of certified organic feed. Aside from the requirements for net cage culture, farmers growing products in ponds tend to seek increased production through modest additional feeding as such a semi-intensive mode provides better returns and enables to meet growing market demands. Global demand for organic aquaculture feed by far outstrips supply, and ingredients are sourced on the global market, whereas organic principles aim at reducing environmental costs of long-distance shipment. Additionally this adds considerably to the costs of production and the quality of the feed can potentially suffer due to transit times and transport conditions en route (e.g. by moulds that produce aflatoxins). However, in a country with only one or a few organic aquaculture farms the initial establishment of the first local organic aquaculture feed production facility is a tedious process as existing feed mill operators hesitate the part-time production of relatively low amounts of feed due to the stringent requirements in preparing machines between runs of organic and non-organic feed to avoid contamination. Additionally, the sourcing of ingredients at national or local level which satisfy requirements of organic labels can pose serious obstacles for start-ups, notably in developing countries.

The recently completed project financed by the Common Fund for Commodities involved organic farms in Thailand (shrimp), Myanmar (shrimp) and Malaysia (tilapia and shrimp). In Thailand the project was successful in obtaining organic certification for the involved stakeholders and in establishing contacts with buyers in international markets. In Malaysia and Myanmar good potential was identified for the relevant parties. The main obstacle encountered was the difficulty in obtaining organic feed at a reasonable cost. On the plus side, domestic and regional demand for organic aquaculture products was much stronger than anticipated.

Organic aquaculture and markets have met the expectations and commitments expressed in The Bangkok Declaration of 2000, including: improved environmental sustainability, strengthening of institutional support to implement transparent and enforceable policy and regulatory frameworks, application of rules and procedures, application of innovations in aquaculture, better management of aquatic animal health; improved nutrition in aquaculture, improved food quality and safety, and the promotion of market development and trade.

In future, the largest increases in production volume are projected for two species: Atlantic salmon and “shrimp”. The global market value of organic aquaculture is expected to increase by 40 to 60 percent over the three years between 2009 and 2012 surpassing a total value of €500 million in 2011. However, in the near future, better strategies will have to be developed to avoid the bottleneck of insufficient organic aquaculture feed supply, notably in the budding organic aquaculture sector in developing countries. Benchmarking of existing labels and standards and cross-accreditation will enable farms to access additional market

channels without the need for new and costly certification procedures. Establishing such equivalency as well as harmonisation is necessary, particularly for the increasing number of national organic aquaculture labels. Although considerable scope exists for development of organic agriculture markets in developing countries due to increasing numbers of middle class consumers, experience has shown that the initial growth and expansion is in other organic food categories, such as grains, dairy products, fruit and vegetables, and only in a secondary phase in meats and aquatic products. Raising consumer awareness and establishing trust can accelerate this process.

Expert Panel Presentation V.1

Investing in Research, Communications, Training/Extension for Responsible Aquaculture

LEAD PANELLIST: BRIAN DAVY

PANEL MEMBERS: V. BHAT, YUAN DERUN, SENA S DE SILVA, COURTNEY HOUGH, RODRIGO INFANTE, BRETT INGRAM, N. T. PHOUNG, DORIS SOTO, GUZEL YUCEL-GIER

Davy, B., Bhat, V., Derun, Y., De Silva, S.S., Hough, C., Infante, R., Ingram, B., Phoung, N.T., Soto, D. and Yucel-Gier, G. 2010. Expert Panel Presentation V.1. Investing in research, communications, training/extension for responsible aquaculture. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Like all spheres of human endeavour, knowledge has also been critically important to the development of aquaculture, irrespective of whether we are talking about the earliest aquaculture innovations starting in China or Egypt or the breeding and disease challenges in the 1970s and 1980s and now in more recent times. However, few scholarly investigations probe aquaculture development through a knowledge lens. Other sectors such as business are examining knowledge in detail (see for example, the knowledge economy thinking), but this issue seems to be a relatively untouched line of scholarly investigation by researchers in the aquaculture sector.

Knowledge generation is increasing exponentially and aquaculture is no exception. Identifying and applying the needed knowledge, and even just keeping up with present continuing challenges is not an easy task for most of us, and particularly for many of the newer aquaculture stakeholders, particularly in a globalised world where communication channels have increased, diversified and are easily accessible to most. Looking back to Kyoto (June 1976) and the last global conference, the Millennium Conference (February 2000), there was a clear recognition of the importance of networking and related forms of knowledge sharing and learning. This panel reviews the cases of the Network of

Aquaculture Centres in Asia-Pacific (NACA; www.enaca.org) and EATIP (European Aquaculture Technology and Innovation Platform (www.eatip.eu)) as two examples of ongoing knowledge sharing networks using knowledge platforms and different knowledge management activities. It is expected that such networking and wider knowledge sharing activities will intensify in the coming decade, guided by the goals set out in the Bangkok Declaration, and hopefully further refined and improved at this Conference.

Our panel also reviewed other knowledge and communications experiences through an examination of cases on marine cage farming in Turkey/Mediterranean, salmon farming in Chile, small-scale shrimp culture in India, catfish farming in Viet Nam and aquaculture farming in Europe. Local knowledge, particularly farmer-based knowledge, some of which has a long history, but in more recent times supported by “good science”, in many cases produced through various international partnerships, is highlighted. Our review raises a number of questions, such as whether aquaculture as a sector is adequately examining/managing available knowledge; for example, traditional knowledge sources or some of the new thinking in the social and information/communication sciences.

Aquaculture has been and seems likely to continue to be a story of growth, extremely rapid growth in some cases with both positive and negative impacts, but in other cases, much slower development phases of 25-40 year cycles. Our selected cases raise a variety of sector growth questions around knowledge production and particularly, its communication and use (for example, in new training and extension thinking) and more importantly, its communication among the changing audiences, as aquaculture continues to attract an increasing variety of new stakeholders, as it attempts to deal with a widening set of change processes often involving a complex mix of governance and social change challenges. We go on to suggest that aquaculture stakeholders need to better understand some of these knowledge processes, such as knowledge translation, the use of knowledge platforms and brokers. All are suggested as potential knowledge strategies likely increasingly critical to the sustainable development of aquaculture and its movement towards attaining the goals set out in the Bangkok Declaration.

Investment in basic research is at all times very relevant, and governments should strengthen funding for this kind of research. However, a more applied and directed research is also needed and some countries have found mechanisms to support this, in some cases through public-private partnerships. Such research is very relevant to the solution of very practical problems for the farmers; for example, the development of a needed vaccine or the production of a type of feed for larvae.

Our cases suggest an initial set of lessons learned that reaffirm the fundamental importance of knowledge, both from the research sector and also from local or indigenous farmers plus other stakeholders. Knowledge sharing seems poised to expand at all levels and scales, but we can expect a variety of challenges in optimal knowledge sharing, not only around the rapid growth in aquaculture, particularly given the increasing number of stakeholders, but

the accompanying pressures (e.g. market pressures that increasingly cross scale, time and level boundaries), most of which have received little attention to date.

At the regional scale for the coming decade, the newly formed Network of Aquaculture in the Americas and the plans in Africa for redevelopment of similar knowledge-sharing mechanisms provide further future case material for continued examination and lesson learning with and between regions; regions in which aquaculture will continue to follow different but knowledge-linked paths. Work to date around various start-up interregional knowledge sharing activities suggests a future set of activities for development of optimal knowledge networking globally.

Finally we suggest a number of new future directions in which aquaculture could learn a great deal from related knowledge management in other sectors. For instance, we review some of the work in the health sector with a particular focus on the knowledge sharing and knowledge translation thinking leading to strengthened knowledge management related to policy change as well as implementation. We see major gaps in aquaculture work to date around what we are calling “aquaface thinking” (a term borrowed from work at the coal face), where knowledge management strategies are strongly linked to this aquaface or implementation science.

Expert Panel Presentation V.2

Servicing the Aquaculture Sector: Role of State and Private Sectors

LEAD PANELLIST: MICHAEL PHILLIPS

PANEL MEMBERS: RANDALL BRUMMET, WILLIAM COLLIS, HARVEY DEMAINE, ALEX FLORES-NAVA, DOMINIQUE GAUTIER, COURTNEY HOUGH, LE THANH LUU, ZURIDAH MERICAN, P.A. PADIYAR, ROY PALMER, JHARENDU PANT, BEN PONIA, PADDY SECRETAN, ROHANA SUBASINGHE, N.R. UMESH

Phillips, M., Brummet, R., Collis, W., Demaine, H., Flores-Nava, A., Gautier, D., Hough, C., Luu, L.T., Merican, Z., Padiyar, P.A., Palmer, R., Pant, J., Ponia, B., Secretan, P., Subasinghe, R. and Umesh, N.R. 2010. Expert Panel Presentation V.2. Servicing the aquaculture sector: role of state and private sectors. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/ Thailand Department of Fisheries. Phuket, Thailand.

The term “services”, according to OECD, covers “a heterogeneous range of intangible products and activities that are difficult to encapsulate within a simple definition. Services are also often difficult to separate from goods with which they may be associated in varying degrees”. In aquaculture, such services encompass a range of different products and activities that can be broadly assigned, albeit with some overlap, to the following

service categories: (a) traditional “extension”, (b) financial, (c) market, (d) business, (e) input provision, (f) infrastructure and transport, (g) technical, (h) harvest and post-harvest processing, (i) research and (j) information.

The reality is that the aquaculture sector has and needs a diverse range of services that are important from planning through to operation of aquaculture enterprises, and throughout the whole “value chain” of aquaculture from input supplies and production systems, to post-harvest handling, trading and processing, marketing and consumption. They are relevant, in various ways, for all types of aquaculture systems and species, at all scale, from subsistence farming through the spectrum of aquaculture enterprises from micro and small-scale household-managed farms, to medium and large-scale business. Services have been and always will be an essential part of aquaculture development, and successful aquaculture development requires that the services needed are in place.

Public and private sectors, including non-governmental agencies (NGOs), are all involved in provision of aquaculture services, although roles and responsibilities differ. Services are provided at various levels, from local community level or farmer organisations through to large multinational business, regional and international organisations. They are delivered in a multitude of ways and technologies, from direct interactions between a community-based “extension” officer and a small-scale farmer, to globally managed market information services using the latest Internet and communication technologies. They may also delivered by institutions specialising in aquaculture, or public and private organisations engaged more widely in other sectors.

Growth in aquaculture over the past 10 years, under the influence of a range of global drivers, has changed not only the nature of services required but also the way in which these services are delivered. In less-developed and newly emerging aquaculture countries, there are still considerable gaps in services, particularly in rural areas. In others, market and competitive pressures, such as the recent moves towards certification and food safety and quality assurance, have created new requirements for services for aquaculture.

There have also been some major changes in the way that services are delivered to aquaculture farmers, and opportunities emerging for improvements in addressing new needs, and filling existing gaps, particularly with the rising role of communication technologies and Internet. Investments in capacity building and easier access to information and better communication have contributed to rising capacity in Asia for management of the sector and delivery of services both in the public and private sectors. Within Europe, on-line sales and traceability services are providing new means for distance selling but evidently require adaptation of the way in which sales and marketing are viewed by the operator. Market requirements and disease problems have increased the need for both the public and the private sector to develop technical and analytical services for aquatic animal health management and food safety assurance. In many countries, the government role in extension services has reduced during the past 10 years, while the role of private business

has increased. Many rural farmers though still lack access to the necessary services, a problem widely felt throughout the agriculture sector in many developing nations.

The Bangkok Declaration does not refer specifically to services as such, but services are directly and indirectly referred to in various elements of the Strategy for Aquaculture Development Beyond 2000. In general, there has been progress in many aspects of service provision; however, it is questionable whether “improving the capacity of institutions to develop and implement strategies targeting poor people” as stated in the Strategy has improved, or that the approaches tried to address such capacity deficits have been widely effective. What are the future expectations for the topic?

Future growth of aquaculture will require improved services and a better coverage of the sector, with investments and responsibilities involving both public and private sectors. Regardless of species and production systems, better integration to market supply chains will require a rapid intensification of wide range of services. Environmental sustainability issues, such as accessing sustainable feedstuff sources, will require better and more comprehensive solutions, linked to environmental and fishery sciences, agriculture and biotechnology. Genetics and husbandry in general are a fundamental basis for aquaculture development and will continue to require investments in research and technical services. Gaps in service provision for micro and small aquaculture enterprises, largely involving households, also need to be addressed. Services may be aquaculture specialised or likely in rural areas of many countries with large rural populations, may be part of a spectrum of advisory services. More business-oriented solutions will be needed for sustainability and accountability.

The paper will provide suggestions on the way forward for further discussion at the Conference, including the need for continued public and private-sector investment in services, the urgent need to address uneven provision and access to services for micro and small-scale aquaculture enterprises, the importance of business-oriented approaches and encouraging further investment by the private sector in services, and the need for government policy orientation towards improving and continued public investment. Considerable opportunities for cooperation still exist in service provision, and the panel discussions and conference debates will hopefully identify new ideas and partnerships that will provide the basis for moving forward.

Expert Panel Presentation V.3

Progressing Aquaculture in This Knowledge Economy Through Virtual Technology and Decision-Making Tools for Novel Management

LEAD PANELLIST: J.G. FERREIRA

PANEL MEMBERS: J. AGUILAR-MANJARREZ, C. BACHER, K. BLACK, S.L. DONG, J. GRANT, E. HOFMANN, J. KAPETSKY, P.S. LEUNG, R. PASTRES, Ø. STRAND, C.B. ZHU

Ferreira, J.G., Aguilar-Manjarrez, J., Bacher, C., Black, K., Dong, S.L., Grant, J., Hofmann, E., Kapetsky, J., Leung, P.S., Pastres, R., Strand, Ø., Zhu, C.B., 2010. Expert Panel Presentation V.3. Progressing aquaculture in this knowledge economy through virtual technology and decision-making tools for novel management. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries, Phuket, Thailand.

Attention is presently turning to the processes, methods, and tools that allow the principles of the ecosystem approach to aquaculture to be translated into practical implementation. An essential element for this is the use of virtual technology and decision-support tools, particularly if developing nations are to promote the key elements of aquaculture sustainability.

We provide an overview of current and emerging issues and trends related to this topic over the past decade, an assessment of progress with regard to the expectations and commitments expressed in the Bangkok Declaration and conclude with some thoughts for the future.

‘Virtual technology’ is the means by which conceptual models can be made more formal and tested against reality. It involves the collection of data, the integration of these data within a system (information system), the formalisation of the system and the action on the system (simulation) with a given purpose. In this review, we therefore address two different types of tools: (a) modelling tools (the way by which information is used for a given purpose – modelling is used here in a very broad sense) and the link to data collection technology, and (b) tools which allow measurements to be made and translate data into information (information and communication technology).

Natural resource managers, aquaculturists and other stakeholders pose questions on water quality diagnosis, growth and system carrying capacity and environmental effects, local-scale interactions, prediction of harmful algal blooms, disease control systems, environmental product certification, socio-economic optimisation, spatial definition of natural and human components of ecosystems and of competing, conflicting and complementary uses of land and water. A good many of these can be addressed, at least in part, by means

of virtual technologies and decision-support tools. Different stakeholders need replies to these questions at differing time and space scales; for instance an environmental manager for an estuary or coastal bay might be interested in system-scale carrying capacity, both in terms of production and environmental impact, while at the level of ICZM the role of bottom-up (e.g. nutrient-related) effects and top-down (e.g. shellfish grazing) control might be an important consideration. Farmers will be more concerned with optimising production and profit, disease control and market acceptance. Farmers and managers in the west may be more focused on open coastal systems, whereas in Asia, Central and South America or in Africa, the emphasis may be more on inland or fringing systems such as shrimp and/or fish pond culture.

The data that are needed for management and decision-making are similar across most aquaculture operations. However, the space and time resolution of the data sets are dependent on the scale of the aquaculture operation. Consequently, the data acquisition approaches and needs expand with the scale of the aquaculture operation, and become a system-scale requirement when placed in the context of spatial planning, ecosystem-scale carrying capacity assessment and ICZM.

Examples of key applications focusing on specific issues are provided and contextualised by means of case studies addressing a range of culture types and cultivated species; these consider aquaculture sustainability at the system-scale and farm-scale, deal with open water and land-based pond culture, and with forecasting at the scale of the cultivation cycle and real-time evaluation of animal welfare.

The Bangkok Declaration (NACA/FAO, 2000) aims to ensure the sustainable development of aquaculture over a ten-year horizon. Among the 17 strategic elements of the Bangkok Declaration, none of them made explicit reference to the use of virtual technology, since this area was only starting to emerge. However, it is clear that virtual technologies and decision-support tools for novel management are directly related to a number of strategic elements such as: applying innovations in aquaculture, investing in research and development, and improving information flow and communication.

The main constraints in the application of virtual technology in developing countries are identified, together with potential ways to address such problems. The aquaculture industry is going to be affected by many different issues and trends over the coming years, often operating concurrently, sometimes in unexpected ways, and producing changes in the industry that may be very rapid indeed. Without a doubt, virtual technology and decision-support tools will play an important role in addressing many of these, and will therefore underpin many of elements of the Bangkok Declaration and Strategy. Some of the directions and challenges are: innovations that will drive virtual technology, information exchange and networking, links between industry and research centres, collaboration between developed and developing countries, and strategic alliances in developing countries, making virtual technology tools more production- and management-oriented. Even if attractive and promising, these tools will have to be adapted to local realities and conditions to really

become useful (and used) in the future. This requires a compromise with respect to ease of use, data requirements and scientific complexity. A few of the gaps identified in this review are: disease and harmful algal bloom modelling, use of models for certification and traceability, and modelling with data scarcity.

In the future, virtual technologies will play an increasingly important role in the prediction of potential aquaculture siting and production, environmental impacts and sustainability, and the next decade will bring about major breakthroughs in key areas such as disease-related modelling, and witness a much broader use of virtual technology for improving and promoting sustainable aquaculture in many parts of the world.

Expert Panel Presentation V.4

Information and Data Needs: A Strategy for Improving Aquaculture Statistics

ZHOU XIAOWEI AND ROHANA SUBASINGHE

Zhou, Xiaowei and Subasinghe, R. 2010. Expert Panel Presentation V.4. Information and data needs: a strategy for improving aquaculture statistics. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/ Thailand Department of Fisheries. Phuket, Thailand.

While significant progress has been made on improving the data and information needs for promoting sustainable aquaculture worldwide, there remains much work to be done to further improve the knowledge base on aquaculture. Recently, on the advice of the members, a Strategy and Outline for Improving Information on Status and Trends of Aquaculture has been developed by FAO. The Strategy has been elaborated within the framework of the Code of Conduct for Responsible Fisheries, and taking into account the process undertaken resulting in the Strategy for Improving Information on Status and Trends of Capture Fisheries, which was formally accepted by the FAO Committee on Fisheries in February 2003. The Strategy applies to the assembly and dissemination of information on the status and trends of aquaculture. Data collection needs for aquaculture are primarily for national policy making, planning and management of the aquaculture sector and at the global level are established by existing obligations of states to report fisheries statistics to FAO under Article XI of the FAO Constitution. The Strategy proposes to significantly improve data collections and related research for the benefit of users at the national, regional and global levels. This should include additional support from relevant international organisations and financial institutions for capacity building in developing countries.

The Strategy is global in scope and is designed to cover all aquaculture production practices, for food and non-food uses, in fresh, brackish and marine waters including all commercial and small-scale aquaculture. It states the needs for information and statistics data in areas including social and economic aspects, impacts and utilisation of natural resources, especially land and waters, and impacts and utilisation of ecosystems and bio-diversities. It addresses national capacity for the collection, processing, analysis and dissemination of information, quality, completeness and scope of data and information, timeliness of information collection and dissemination, national and international institutional frameworks for coordination of data and information collection, and participation and transparency in the preparation of global status and trends reports.

The overall objective of the Strategy is to provide a framework for the improvement of knowledge and understanding of aquaculture status and trends as a basis for policy-making and management, and to ensure development that is compatible with good stewardship of resources and the environment.

The Strategy will be implemented through arrangements between states, directly or through their participation in regional fisheries organisations, and FAO. These arrangements should be established at various geographic scales, ranging from local to national to regional, and they should be linked to form a global system under the auspices of FAO. Consistent with Article 5 of the CCRF, the capacity of developing countries will be taken into account in implementing the Strategy.

The Strategy categorises actions to be undertaken into three broad categories: (a) Capacity building in developing countries - critical to fulfil national needs and existing reporting obligations, and to ensure that developing countries can fully participate in, and benefit from, the Strategy; (b) global methodologies and standards - gaps and constraints in the data collected should be addressed, in addition to evaluating what data should be collected in the context of national needs and priorities, data collection cost and national capacity. FAO, with its partners, should develop harmonised standards, definitions and methodologies and software for the compilation, processing and analysis of aquaculture statistics, and should promote its adoption and application by member countries; and (c) improving institutional mechanisms and procedures for statistics and status and trends reporting – FAO should consider establishing an inter-regional Coordinating Working Party on Aquaculture Statistics to review requirements for aquaculture statistics, agree on standard concepts and definitions, and make proposals for the coordination of aquaculture statistical activities among relevant organisations under the international mechanism of Coordinating Working Party on Fisheries Statistic (CWP). States should agree on arrangements to facilitate the provision and exchange of information on aquaculture with FAO, and should monitor these systems to ensure their sustainability for meeting the needs of aquaculture policy-making and management.

Expert Panel Presentation VI.1

Protecting Small-Scale Farmers: A Reality Within a Globalised Economy?

LEAD PANELLIST: ROHANA SUBASINGHE

PANEL MEMBERS: IMTIAZ AHMAD, JOHN ARNOLD, LAILA KASSAM, SANTHANA KRISHNAN, KIRBY LANEROLLE, LEENA NAIR, BETTY NYANDAT, ARUN PADIYAR, MICHAEL PHILLIPS, WARAPORN PROMPOJ, MELBA REANTASO, MIAO WEIMIN

Subasinghe, R., Ahmad, I., Arnold, J., Kassam, L., Krishnan, S., Lanerolle, K., Nair, L., Nyandat, B., Padiyar, A., Phillips, M., Prompoj, W., Reantaso, M. and Weimin, M. 2010. Expert Panel Presentation VI.1. Protecting small-scale farmers: A reality within a globalised economy? Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Aquaculture is the fastest growing food producing sector in the world, and over 80 percent of global aquatic produce originates from Asia. Between 70 and 80 percent of Asian farmers are estimated to be small-scale farmers. Aquaculture products are now recognised as truly globally traded commodities. In the coming decades, aquaculture is expected to bridge the global aquatic food supply and demand gap created by stagnant capture fisheries production, in order to feed the continuously growing human population.

The past few decades have shown a clear growth in overall global food production; however, the per capita gross national product (GNP) increased only in the OECD countries and to a lesser extent in Eastern Europe and Asia. While the numbers of people in poverty have declined in East and South Asia, global poverty has certainly not been reduced, and eradicating poverty and hunger still remains the most challenging and fundamental global humanitarian task. Aquaculture has the potential to play an important role in contributing to this daunting task through provision of food for the poor, as a source of livelihood for the many producers and people involved along the aquaculture value chain, and as a source of wider economic growth, stimulating growth in other sectors through production and consumption linkages.

The positive impacts of globalisation include worldwide marketing of goods and services; increased economies of scale; and corporate governance of the industrial food production sectors taking advantage of inexpensive labour, capital and technology. There is, however, good evidence that while industrial and corporate sectors continue to benefit from globalisation, small-scale producers are slowly pushed out of business due to competition.

The combined effects of trade liberalisation and globalisation have increased economic differentiation among communities and households. In addition, state withdrawal from agricultural marketing has contributed to a highly uncertain environment in which input and output prices are determined by the market, often favouring large-scale producers who are better equipped to manage price variability and/or absorb price shocks, and gain through efficiencies of scale in commodity production.

It is clear that increasing globalisation and the resultant trade liberalisation of aquaculture products is leading towards the marginalisation and exclusion of individual small-scale producers. They face major challenges to remain competitive and able to participate in modern value chains, globally. The situation is particularly serious in Asia, due to the large numbers of people involved, but the trend affects farmers across the aquaculture-producing regions. This is partly due to integration of production-distribution chains and coordinated exchange between aquaculture farmers, processors and retailers, and is evident in the higher-value internationally traded export species such as shrimp, although is now also affecting low-value species such as catfish and tilapia.

Small-scale producers also face challenges related to changing preferences of consumers for safer, healthier, better quality food produced in environmentally sustainable and ethical ways. This has resulted in increased demand for food safety and environmental standards, or “niche” products that have special characteristics based on their quality, farming practice and origin. These characteristics are strongly linked to how products are being produced rather than to the end product itself, thus, putting greater emphasis on traceability. Growing customer awareness has also led to the development of several aquaculture certification schemes, making it no longer enough for aquaculture farmers to pay attention solely to efficient production. These increased demands for meeting food safety standards, traceability, certification and other non-tariff requirements are driving risks and costs down the market chain to the farmer, favouring medium- to large-scale, capital intensive operations that can afford such extra costs and excluding small-scale farmers who have limited resources and capacity to meet these requirements.

There is a need for changing the management of both large- and small-scale producers to remain competitive. Large-scale farmers have a much higher adaptive capacity to benefit from such trends than do small-scale farmers. Small-scale aquaculture farmers are not only exposed to increasing market risks, but also face enormous constraints in accessing markets and services and integrating into modern supply chains. In many cases, they are ill-equipped to benefit fully from the new market environment and knowledge because of lack of public and private policy and services to support investment and change, resulting in potentially significant social risks for many rural producers.

Despite these challenges, the aquaculture sector is growing; small-scale aquaculture remains highly innovative and contributes significantly to global aquaculture production, although increasingly less so in many export products. There are many opportunities to improve management and governance, thus increasing social and economic benefits

to small-scale farmers. One such opportunity lies in promoting collective action among small-scale producers to create efficiencies of scale, and orienting investment and support empowerment of farmers in self-help groups, clusters or societies.

Recent experiences show that application of better management practices (BMPs) through establishment of farm clusters and farmer societies are effective in improving aquaculture governance and management in the small-scale farming sector. This enables farmers to work together, improve production, and develop sufficient economies of scale and knowledge to participate in modern market chains and to reduce vulnerability. Such governance and management approaches improve the economic performance of the sector and strengthen producers' ability to participate in decision-making and self-regulation. Once such approaches are established and strengthened, a competitive small-scale farming sector will become a reality.

Expert Panel Presentation VI.2

Alleviating Poverty Through Aquaculture: How Can We Improve?

LEAD PANELLIST: DAVID LITTLE

PANEL MEMBERS: IMTIAZUDDIN AHMED, BENOY BARMAN, BEN BELTON, MALCOLM BEVERIDGE, RANDY BRUMMETT, SIMON BUSH, HARVEY DEMAINE, PETER EDWARDS, GULAM KIBRIA, JACK MORALES, FRANCIS MURRAY, MUDNAKUDU NANDEESHA, SUGIYAMA SHUNJI, ROHANA SUBASINGHE, FATCHURI SUKADI

Little, D., Ahmed, I., Barman, B., Belton, B., Beveridge, M., Brummett, R., Bush, S., Demaine, H., Edwards, P., Kibria, G., Morales, J., Murray, F., Nandeesha, M., Shunji, S., Subasinghe, R. and Sukadi, F. 2010. Expert Panel Presentation VI.2. Alleviating poverty through aquaculture: How can we improve? Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

Aquaculture as a household, community and agribusiness-based activity to supply human food and other products and contribute to the alleviation of poverty is explored in this overview.

Definitions and concepts regarding the nature of poverty and its alleviation are first considered in the context of recent ideas about what poverty is, on whom and where it occurs and impacts, how it can be measured and what strategies have proved most useful in mitigating its effects. The impacts of poverty on food security and broader development outcomes are considered in the context of “well being”. The expectation that aquaculture in LDCs is practiced in rural areas for and by poor people as part of a “small-farm” development model is critically examined, and alternative models for aquaculture

development to alleviate poverty are considered. The explicit linkages between “rural” and “small-scale” characteristics of aquaculture and poverty alleviation are interpreted and challenged.

Aquaculture is considered from the perspectives of consumption, market, scale, operational mechanism, role within the farming and/or livelihood system, stage and management of culture. Impact boundaries for aquaculture are considered, as is the concept of indicators that can map positive and negative impacts of aquaculture development on people with stakes in value chains.

The multiple natures of poverty and the concepts of escaping from and slipping into poverty are explored with reference to aquaculture contexts. Aquaculture as a strategy to reduce poverty of a targeted group rather than merely alleviating its impacts is discussed. Temporal and multi-generational aspects of poverty are reviewed with respect to traditional aquaculture/fishery systems. The potential for aquaculture to exacerbate or alleviate poverty at the household and community levels is considered, and the issue of risk and risk mitigation explored with regard to both. The conflicting and complimentary characteristics of aquaculture activities within complex livelihood portfolios are assessed.

The particular relationships between poverty, food security and aquaculture development are discussed with regard to household farmed and alternative sources of aquatic foods (fisheries, purchased) and integration with horticulture. Food security and self-sufficiency are compared in the light of trends toward urbanisation and industrialisation.

The evidence for aquaculture being a cost-effective approach to poverty reduction is examined for various contexts and the issue of targeting households, communities and agroecological contexts reviewed. Impacts of field-tested approaches to extension focusing on poverty alleviation will be assessed and the roles of farmer field schools, social/participatory learning and network approaches considered. The relative importance of immanent and interventionist approaches are questioned.

Aquaculture as a driver for development is reviewed, based on various case studies, and found to contribute to poverty alleviation in both transformative and incremental modes and at various scales. The heterogeneity of commercial aquaculture that has developed in the last decade to serve rapidly growing urban and international markets has been transformative at household, community and often national levels, impacting on many aspects of poverty. Predisposing factors such as location, water and infrastructure availability and market development are assessed and discussed, as are the roles of promoter organisations and institutional context. The future impact of high-potential clusters on surviving smaller-scale enterprises and opportunities for poorer groups is considered in the light of value addition in processing industries. The implications for poorer people as transformational aquaculture leads to changing access to resource and markets, particularly land, water and labour will be discussed. Given the criticisms of, and longer term constraints to, conventional intensification, alternative and/or parallel scenarios are considered,

including those based on culture-based fisheries and in comparison with the livestock sector. Evidence for consolidation in areas of industrial aquaculture adoption and concurrent resilience/vulnerability among smaller-scale producers will be reviewed and implications for poorer people assessed.

The incremental benefits of aquaculture as a part of the complex dynamic livelihoods of the poor are investigated and their sustainability questioned in regard to the aspirations of the poor and trends in agriculture generally. The frequently low relative importance of smaller-scale aquaculture in household income streams, frequently less than 10 percent, is dissected with regard to other motivations for hanging in, stepping up or stepping out. Relationships to other sources of aquatic animals, typically wild or managed fisheries are assessed, as are alternative resource management approaches.

Aquaculture within integrated water and other resource use has long been advocated, but the long-term resilience of managed aquatic systems that incorporate aquaculture could have important implications for future levels of urban and rural poverty.

Expert Panel Presentation VI.3

Addressing Human Capital Development and Gender Issues in the Aquaculture Sector

LEAD PANEL EXPERT: KYOKO KUSAKABE

EXPERT PANEL MEMBERS: RENE AGBAYANI, RAM BHUJEL, CECILE BRUGERE, POH SZE CHOO, JEAN DHONT, KIBRIA GHULAM, KYOKO KUSABE, DAVID LITTLE, M.C. NANDEESHA, MELBA REANTASO PATRICK SORGELOOS, ANGEL GALMICHE TEJEDA, NIREKA WEERATUNGE, STELLA WILLIAMS, PAO XU

Kusakabe, K., Williams, M., Agbayani, R., Bondad-Reantaso, M.G., Bhujel, R., Brugere, C., Choo, P.S., Dhont, J., Ghulam, K., Kusabe, K., Little, D., Nandeesha, M.C., Sorgeloos, P., Tejada, A.G., Weeratunge, N., Williams, S., and Xu, P. 2010. Expert Panel Presentation VI.3. Addressing human capital development and gender issues in the aquaculture sector. Book of Abstracts, Global Conference on Aquaculture 2010, 22-25 September 2010. FAO/NACA/Thailand Department of Fisheries. Bangkok, Thailand.

In 2004, the FAO Advisory Committee on Fisheries Research oversaw the development of the FAO Human Capital Development Strategic Framework, but little follow-up occurred internationally. However, in most countries and regions, targeted aquaculture training activity and education courses increased and intergovernmental and professional networking strengthened and matured (e.g. NACA, AFS, WAS, SEAFDEC, private sector etc). In Europe, aquaculture tertiary education institutions are becoming strongly integrated and

reaching out to other regions, especially Asia. Education and its institutions need special attention, since they are the foundation for research and development and help to create the norms for professionals. Unless efforts are made to develop quality human resources, aquaculture developments that have taken place in Asia and elsewhere, largely because of the innovations made by the farmers, will not be sustainable, since there is a limit for farmer innovations. Investment in education to produce quality human resource can have profound impact on aquaculture.

Akin to farming and fishing, aquaculture is usually assumed to be largely the domain of men. Minimal progress has been made in addressing gender issues in aquaculture, even though some researchers, activists and development agencies are recognising and raising the profile of the issues. Yet, women's participation in fish farming has increased, raising the question as to whether women are receiving training, access to credit, investment capital and adequate trade and business opportunities. However, despite increased participation and some outstanding examples of women entrepreneurs in some businesses, many women still receive low economic returns from aquaculture and experience poor working and social conditions in the industrial aquaculture sector (post-harvest and processing). In higher education, the time series of statistics commencing in the 1970s shows that women are making up a greater number of students in some of the key aquaculture programmes, but employers in the sector often don't want to put women in the field for safety reasons, thus impeding their career paths and losing potential talent. Some progress has been made in raising awareness of women's and children's roles in aquaculture and in developing good practice guides, (e.g. 3 AFS Symposia on Women/Gender and Fisheries; EU (2005) Gender, Fisheries and Aquaculture: Social Capital and Knowledge for the Transition towards Sustainable Use of Aquatic Ecosystems; FAO (2007) Gender Policies for Sustainable Fisheries and other efforts by the FAO Sustainable Fisheries Livelihoods Programs of west and central Africa and WB-FAO-IFAD (2009) Gender Sourcebook in Agriculture that covered fisheries and aquaculture). Much of this work has been developed to also cover fisheries, and indeed gender issues tend to have received greater focus in fisheries than in aquaculture, although even the fisheries treatment has been slight. Only a little progress has been achieved in gathering gender-disaggregated national statistics and information at other levels, and in developing gender-based norms for the sector. Unlike in the water, household energy and to some extent agriculture sectors, the aquaculture and fisheries sectors have not developed manuals or guides to collecting gender-disaggregated information.

In science, some gender-disaggregated statistics are collected by the Agricultural Science and Technology Indicators programme (<http://www.asti.cgiar.org/gender-capacity>). Gender equity is a long way off. Gender awareness has yet to be translated into more visible actions that are well-informed by knowledge of the realities on the ground. For example, women's participation in such activities as harvesting, marketing and pond record keeping may increase, but they are still controlled by men. Women's control over resources and decision making needs improvement. The more fisheries professionals are aware of power issues, the more their research and interventions can address them. The last decade has seen more women in professional positions, training programmes and networks, but most

small-scale studies have also indicated that women's training generally lags behind that of men, partly from low targeting of women for aquaculture technology transfer (extension and adoption). For their part, women may be reluctant to attend the training programmes due to heavy responsibilities at home, but this and other constraints need to be better understood. In the recovery efforts after major natural disasters and calamities, more attention has been given to human capital development (HCD) and gender, such as in dealing with HIV/AIDS and in the reconstruction after the Indian Ocean tsunami.

Aquaculture is the fastest growing agricultural sector in the world. How do we ensure that the benefits from aquaculture growth are pro-poor and gender equitable? HCD and gender issues are at the heart. FAO should therefore create gender and HCD positions to lead the global efforts. In so doing, FAO should look not only at production, but deliberately include the whole supply chain and its support services and address issues such as the implications of climate change and gendered impacts and responses, including the education and training functions when formulating its programme priorities. Professional bodies should follow the Asian Fisheries Society lead and host substantial sessions on gender and aquaculture within their conferences, publications and work programmes.

While the thematic review and presentation will address HCD and gender issues separately as each are large and important areas for aquaculture, the experts will also look at the intersection – gender issues in HCD - because it is an important area for both gender and HCD.

Expert Panel Presentation VI.4

Supporting Farmer Innovations, Recognising Indigenous Knowledge and Disseminating Success Stories

LEAD PANELLIST: MUDNAKUDU NANDEESHA

PANEL MEMBERS: CARLOS ALFONSO ALVAREZ, TUNDE ATANDA, RAM BHUJEL, R. BOSMA, N.A. GIRI, CHRISTINE M. HAHN, MATTHIAS HALWART, DAVID LITTLE, PEDRO LUNA, GABRIEL MÁRQUEZ, R. RAMAKRISHNA, MELBA REANTASO, N.R. UMESH, HUMBERTO VILLAREAL, MWANJA WILSON, YUAN DERUN

Nandeesha, M., Alvarez, C.A., Atanda, T., Bhujel, R., Bosma, R., Giri, N.A. Hahn, C.M., Halwart, M., Little, D., Luna, P., Márquez, G., Ramakrishna, R., Reantaso, M., Umesh, N.R., Villareal, H., Wilson, M. and Yuan, D. 2010. Expert Panel Presentation VI.4. Supporting farmer innovations, recognising indigenous knowledge and disseminating success stories. Book of Abstracts, Global Conference on Aquaculture 2010, 22–25 September 2010. FAO/NACA/Thailand Department of Fisheries. Phuket, Thailand.

The term “innovative farmers” refers to those who have tried or are trying out new and often value-adding practices, using their own knowledge and wisdom but also through appropriation of outsiders’ knowledge. It has been recognised that farmers’ innovations are crucial in order to achieve cumulative growth, both economically and socially. In most of the cases, farmer innovations are encouraged by the need to maintain economically viable production. In other cases, social needs such as food security are also drivers for innovation to increase income. Environmental sustainability, like preservation or restoration of local species has also been a driver of innovations in some regions.

However, several social, political, economical and environmental factors have hampered farmers’ innovation, such as lack of information on aquaculture, inadequate science and technology policies and lack of governmental support. At the commercial level, fish farmers frequently indicate that economic constraints limit in-house development or appropriation of knowledge-based technology. In terms of organisation, innovation is a process that requires science to support technology development that is applicable to production.

The panel will assess crucial factors needed to promote, encourage and support farmers’ innovative processes: changes in science and technology laws to promote knowledge-based innovations, specific policies to promote investment in innovation, educational policies focussed on developing specific profiles to manage technology-based aquaculture, appropriate personnel training and extension services, and policies that contribute to the development of aquaculture directed to specific social and cultural groups. Proper design interventions and policies can help to bring in much needed empathetic understanding and

holistic vision to connect and integrate the various innovative efforts towards a positive outcome. These could provide vital directions for developing countries to transform into innovation-driven economies.

The concepts of farmer innovations will be assessed from a broad spectrum of geographical areas and farming systems, describing how these innovations have contributed and can contribute in the future to food security improvement, poverty alleviation and sustainability. The expert panel will examine how interaction between science, technology and production can contribute to innovation in both small-scale and commercial aquaculture.

Equally important is the recognition of indigenous knowledge in aquaculture, and there are numerous examples that illustrate the good use of this knowledge in developing cost-effective and sustainable strategies in poverty alleviation and income generation in both developing and developed countries. The panel will examine how far indigenous knowledge systems have been harnessed in developing aquaculture systems and how indigenous knowledge principles can be used to promote environmentally friendly aquaculture production systems. Indigenous knowledge systems being dynamic, they are constantly influenced by internal creativity and experimentation, as well as by contact with external systems.

Traditional knowledge is an important part of the lives of the poor: it is the basis for decision-making of communities in food security, health, education and natural resource management. The panel will focus on how this knowledge has been adapted, applied and disseminated. The panel will assess with different stakeholders involved in aquaculture, the possibility to further incorporate indigenous knowledge to improve the productivity and sustainability of the aquaculture systems by remaining environmentally friendly.

The examples and case studies to be presented are expected to generate fruitful discussion and provide pathways to build effective partnerships between farmers, researchers and policy-makers. For instance, in African countries, fish culture using substrate-based technologies in open waters demonstrates that culture-based capture fisheries have been traditional and prevalent in many regions. Some of the major traditional knowledge has been subjected to scientific validations, and attempts have been made to improve them through the application of science-based approaches. However, there is a paucity of information on the vast amount of traditional knowledge that is prevalent in different societies of the world.

The panel will assess dissemination strategies, both traditional and emerging approaches that can be effectively harnessed in the aquaculture sector. Studies clearly reflect that wherever farmers have had access to adequate foundation knowledge on the science of a technology, they have been able to constantly improve the production systems, assuring sustainability and the adaptation to local conditions. Relevant examples that demonstrate how successful technologies and practices have been disseminated through different approaches will be presented. For instance, establishment of farmer field schools, cluster approaches and self help groups in many locations of the world as a way to

transfer appropriate aquaculture technology will be discussed and assessed. The report will also present dissemination methodologies followed by some of the most relevant regional aquaculture networks, such as NACA, ANAF and the recent RAA, as well as the EU-supported network known as “SARNISSA electronic network”, created for African aquaculture stakeholders.

The panel will examine the extent that indigenous knowledge, farmers' innovations and innovative dissemination strategies have contributed to the rapid growth of the aquaculture sector in different parts of the world, and how these practices could be adequately documented and disseminated in the future. Further, the panel will assess the need to promote effective partnerships between farmers and the scientific community; while the conventional dissemination strategies would help to spread the technology in a given location, newer institutional approaches and electronic systems can be used to cross geographical boundaries.



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Rainbow trout aquaculture using desert underground brackish water in Iran

MORTEZA ALIZADEH

Inland Salt Water Fishes Research Station, Bafgh, Iran. Email: m_alizadeh47@yahoo.com.

Inland brackish aquaculture may offer an opportunity for income diversification and a potentially productive use of land that can no longer support traditional agriculture in salt-affected parts of inland production and investment levels are characteristically low. It may also provide a means of defraying all or part of the cost of surface and subsurface water management systems. It seems inland brackish aquaculture will be an essential component of salinity management in the future, because unlike many other adaptation strategies, it can be effectively integrated with engineering solutions to treat salinised land. This activity needs to develop in a manner that both prevents the further degradation of agricultural land and provides opportunities for an alternative and sustained economic base for dependent rural communities. Most central areas of Iran are rich in saline water resources with different salinities (5-40g/l). Applying these resources for aquaculture production is a potential adaptive use, although it may be limited by some factors especially strict environmental conditions. So, regarding to well adaptation of rainbow trout to rapid changes in salinity and profitability of its production in state of Iran, this species promoted as potential candidate for aquaculture in these regions. After feasibility studies, complimentary researches carried out during recent decade in Inland Brackish water Fishes Research Station at Bafgh, Iran. According to the results, rainbow trout had a well adaptation in well brackish water (in salinity 14 g/l) without any mortality and the growth performance was desired. It was also introduced the earth pond as culturing system for rainbow trout through semi-intensive method during cold seasons when the cool weather provide a suitable conditions in cultivating ponds. Investigations on increasing production methods in selected system indicated that reusing wastewater and establishing net pen in pond are the effective ways than aeration by submerged and surface aerators. Study on protein and energy requirements of rainbow trout in this medium showed the best growth by fish fed diet with 35% protein and 4,750 kcal/kg digestible energy levels. Considering some gonadic and somatic indices of rainbow trout in mentioned research station proved that as well as maturation speed, body growth and gonad development were faster in utilised medium than fresh water. Findings of this paper demonstrated that by using appropriate semi-annual production system well-set to climate condition, rainbow trout farming in brackish water is a profitable method to develop inland aquaculture industry in Iran.

Keywords: *inland water, aquaculture, rainbow trout, underground brackish water.*

The possibility of tropical fish farming in Greece: the case of Nile tilapia (*Oreochromis niloticus*)

FILOU VARVAYA, TSABALAS GIORGOS, GOUVA EVANGELIA, CHATZOUPOULOS ACHILLEFS, PERDIKARIS COSTAS, PASCHOS IOANNIS

Department of Aquaculture and Fisheries, Technological Educational Institute of Epirus, Irinis & Filias 1, 46100 Igoumenitsa, Greece. Email: paschosi@otenet.gr.

Tilapias (family Cichlidae) are one of the most important warm water cultured species. They are natives of Africa and Asia but they have been introduced into a large number of tropical and sub-tropical areas around the world. In recent years scientists and aquaculture technicians have begun to describe tilapias as the future "aquatic chicken". Among all cultured tilapia species Nile tilapia (*Oreochromis niloticus*) has become the most important because of its hardiness, ease of breeding, high growth rate, the ability to convert organic and domestic wastes into high quality protein and also their good taste. Today, tilapias are cultured in many different culture systems (earthen ponds, raceways, tanks, hapas and cages) and different management strategies are used, depending on environmental conditions, socio-economic factors, technological know-how and market demand. Nevertheless, the expansion of the tilapia culture in temperate regions is constrained by their intolerance to cold. In Greece the culture of tropical species like Nile tilapia, is not widespread, because of their high thermal preference. The use of water recirculating culture system is one possible solution, but in this case the management and operating costs are very high. The aim of the present work is to evaluate the possibility of culture and breeding of Nile tilapia in geothermal waters in Greece.

***Schizothorax zarudnyi* as a potential species for aquaculture**

AHMAD GHARAEI¹, ABDOLALI RAHDARI², MOSTAFA GHAFARI¹

1. Department of Fisheries, International Hamoun Wetland Research Institute, University of Zabol, Zabol, Sistan & Balouchestan, Iran; 2. Department of Fisheries, Faculty of Natural Resources, University of Zabol, Zabol, Sistan & Balouchestan, Iran.

Schizothorax zarudnyi (snow trout) is one of the most important and highly valued cyprinids. It is endemic to Iran and Afghanistan and occurs in Hirmand River and Hamoun Lake. Recently, we carried out artificial propagation of snow trout in order to rehabilitate the natural stocks and also introduce to aquaculture. The female broods were injected with Ovaprim for 2 or 3 times and male broods were injected once before spermiation. All parameters related to hatchery, larval rearing and gro-out to market size were investigated.

Fertilised eggs hatched after 108-130 hours and yolk sac absorption occurred after 18-25 hours at 20±2°C.

The results show that according to biological and feeding behaviours of snow trout, this species can be reared in polyculture associated with warm water fishes such as common carp or monoculture in ponds.

Keywords: Schizothorax zarudnyi, aquaculture, Hamoun Lake, Iran

P-005

Status of aquaculture in Turkey

MEHMET GOKOGLU, YASEMIN KAYA

Akdeniz University Fisheries Faculty Antalya, Turkey. Email: gokoglu@akdeniz.edu.tr.

Turkey, with its favourable geographic position between the Black Sea and Mediterranean Sea, has access to the fish resources of both of these water bodies. The country is also endowed with rich inland waters and river systems with significant capture fishery and aquaculture potential. Marine capture fisheries have an important share in the total fisheries production as the country is bounded by four seas: the Mediterranean to the south, the Aegean to the west, the Sea of Marmara between the European and Asian landmasses, and the Black Sea to the north. Aquaculture is the third component of fisheries production. Aquaculture in Turkey started with rainbow trout culture in the early 1970s and little had happened in terms of sea farming until 1985 beginning with gilthead sea bream and sea bass culture in Aegean Sea. Today both freshwater and sea farming play an increasingly important role in the production of fishery products. The sector can be characterised by mainly three species: rainbow trout, sea bass and sea bream. Production of the three major species increased rapidly during 1990s, efforts have also been given to the development of new species, such as the Black Sea turbot (*Scophthalmus maeoticus*) and some Mediterranean species such as sharpnout seabream (*Diplodus puntazzo*), common seabream (*Pagrus pagrus*), common dentex (*Dentex dentex*) and groupers (*Epinephelus* spp). Northern bluefin tuna (*Thunnus thynnus thynnus*) fattening which started at the turn of the millennium has been the latest development in terms of species diversity. Currently the aquaculture share of total fishery production is around 10–14 percent by volume and around 25 percent by value. The majority of production (about 98 percent) comes from intensive farming systems; rainbow trout is mainly consumed locally, while around 75 percent of seabass and the seabream are exported to EU countries. Almost all the aquaculture products are marketed fresh. The per capita consumption of fishery products in Turkey is around 7 kg. Cultured fish products constitute only around 10 percent of the total domestic fish consumption, which is quite low in comparison to global and European average figures and when compared to Turkey's available aquatic resources. Currently, aquaculture is involved in recreational fishery activities or restocking/ranching operations; however, it is

believed that these may become major development issues in the near future. Aquaculture and related services provide considerable employment opportunities for both local young people and graduates.

P-006

Stunted small male can be a boon or a bane to commercial aquaculture of *Macrobrachium rosenbergii* - a farm level study from India

P. HARIBABU^{1,2}, S.C. MUKHERJEE², K. PANIPRASAD², A.K. REDDY², K. GOPAL RAO³

1. Department of Aquatic Animal Health Management, College of Fishery Science, Sri Venkateswara Veterinary University, Muthukur -524 344 SPSR Nellore District, India; 2. Central Institute of Fisheries Education, ICAR, Mumbai 400 061, India; 3. Dean (Rtd.), Faculty of Fishery Science, Sri Venkateswara Veterinary University, Tirupati 517 502, AP. India. Email: hbabu208@gmail.com.

Farming of giant freshwater prawn *Macrobrachium rosenbergii* (De Man, 1879) has become a significant and valuable sector of global aquaculture. The global expansion rate of this activity was very rapid at annual growth of 48% for the period 1999-2001. India also experienced more or less the same level of expansion with a production of 7,140 t (1999-2000) to 35,870 t (2003-2004). This increase was also reflected in the export of scampi as headless or head-off or tails from India with 2678 t to 10,379 t. The average national productivity of scampi was 860 kg ha⁻¹yr⁻¹ for the year 2003.

Nearly 70 scampi hatcheries registered with Government of India (through the Marine Products Export Development Authority under the control of Ministry of Commerce) with an installed capacity of 1.83 billion post larvae during this period. Around 62% of scampi culture in India was in Andhra Pradesh, of which Nellore region alone accounted for 90% of the culture area of the state.

The farm level commercial success of scampi was short lived and the culture area collapsed during 2003-2005, mainly due to two pathological situations. While the nursery phase was affected by White Tail Disease, the grow-out phase was affected from stunted prawns and the second situation is the topic of discussion in this abstract. A study was conducted as a part of doctoral research and it was found that the small male prawns remained. During normal phase, the farmers were enjoying profits due to the established 'leap frog' growth pattern followed by the stunted small males. In economically failed farms the stunted population especially males remained stunted and the issues related to this problem has been discussed and an attempt has been made to suggest for revival of scampi farming in India. This study is based on the unique opportunity of farm observations interpreting the ecology, biology and growth of male developmental pathway. Continued study of this problem beyond the year 2005 till 2009 gave sufficient strength to propose the correction

methods to revert the small males to follow the normal 'male' developmental pathway or to take the 'leap frog' way.

P-007

Report on preliminary culture of jade perch (*Scortum barcoo*) in controlled aquaculture system

MAUREEN JARAU, JOHANNES G. DON

Fish Protech Pty Ltd, P.O.Box 559, Glenelg, 5045 Australia.

Email: maureen.jarau@gmail.com

Jade perch (*Scortum barcoo*), also known as Barcoo grunter is a freshwater finfish species with a very wide geographical distribution, including Australian tropical waters. It is a hardy, omnivorous species and proved to contain extraordinary high levels of omega-3 polyunsaturated fatty acids (PUFA). This species is commonly reared in open ponds particularly in Queensland, Australia. Due to an increase in the market demand for the taste and its nutritional value, culture of jade perch started to develop in ponds and recirculation systems. In Malaysia, first culture was carried out in an indoor system in 2007. Following the great achievement in growing this species, more interests in continuously rearing the species as part of the fish production has been developed.

This paper describes our observation on the jade perch culture in an indoor system in Malaysia. We have applied Fish Protech–Controlled Aquaculture System (FP-CAS) as our culture system. It is a totally enclosed, controlled environment building and fully integrated recirculation aquaculture system (RAS) with a built in water treatment and distribution system.

Two separate batches of jade perch fry 25-30 mm total body length (TBL) were received from a hatchery in Australia with one month interval of each batch. Fry were quarantined for 2-5 days prior to stocking the nursery tanks. Live samples of fry were sent for disease diagnosis prior to transfer. Once diagnosed free of disease, they were then graded, sampled and nursed in tanks and cages until reaching TBL of 100 mm (20 g). Finally, they were stocked in modules until marketable size of 550 g.

Feeding was first carried out five times a day starting with satiation feeding during nursery period. At the later stages, an average of 2% body weight per day was fed; daily consumption and mortalities were recorded. Water quality was also monitored and recorded daily. Fish were sampled every month to determine mean weight and feed adjustment. The two batches were observed to have shown similar growth performance and reached 500g body weight after 11 months of stocking. Low mortality rate was recorded at 0.15% throughout stocking period. No disease outbreak was observed during the period of introducing the fry into the system until grow out size.

Aquaculture of sturgeon fish as the method of preservation of this relict fish

C. MAMEDOV, G.G. GUSEINOVA, R.V. GADJIYEV, M.M. AKHUNDOV

Azerbaijan Fishery Research Institute under Ministry of Ecology and Natural Resources, Baku City. Email: m_chingiz@yahoo.com.

Presently industrial production is the main source of replenishment of the natural populations of sturgeon fish in the Caspian Sea. But due to the sharp reduction of the number of natural populations in recent years the main factor affecting the activity of sturgeon fish hatcheries is the quality and quantity of sires of different species of sturgeon fish. The spawning herds are getting younger and the base of sires being used for piscicultural purposes in fish rearing stations consist of species which are spawning for the first time. The gametes from these fish, as a rule, are characterised with low piscicultural indices and do not correspond to accepted piscicultural norms.

Aquaculture of the sturgeon plays more crucial part and importance every year in preservation of these relict species (Vassilieva, 2006; Bogeruk, 2006). The strategy of maintenance and replenishment of natural reserves of the sturgeon fish in Azerbaijan like in other pre-Caspian States as well implies: 1) an increase of efficiency in artificial propagation of sturgeon by implementing new and resource-saving technologies in the production; 2) forming broodstock of sturgeon fish in controllable conditions in sturgeon fish hatcheries; 3) development of commercial sturgeon-breeding.

Azerbaijan is the cradle of world sturgeon-breeding. For the first time in the world sturgeon fish hatchery of experimental type was built in the River Kura in 1954. Presently four sturgeon fish hatcheries function in Azerbaijan where nearly all the species of the Caspian sturgeon are bred. Tens of millions of young sturgeon of different species were bred and released to the wild by sturgeon fish hatcheries within the several decades of their exploitation. New Khilli Sturgeon Fish Hatchery was built in 2003 year using the lax credit allocated by the World Bank as investment in nature-conservative measures.

Many world achievements in the field of sturgeon-breeding were introduced in production owing to technical opportunities of new sturgeon fish hatcheries. Lifetime method of obtaining of full roe from the mature sires, domestication of operated sires with the purpose of their repeated piscicultural utilisation, decrease of waste of piscicultural products in the stage of hard-roo incubation, forming recovery-maternal and broodstock of different species of sturgeon fish, as well as endangered species (Kura ship) in factory conditions, introduction of new and more efficient live forage organisms and production of artificial granulated forages taking into account their organoleptic peculiarities for breeding-sturgeon fish is the list of main priority trends of sturgeon breeding which have been implemented in

accelerated rates in sturgeon fish hatcheries of Azerbaijan for recent years (Mamedov et al., 2009; Mamedov and Salmanov, 2009).

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P-009

Upgrading Serbian carp aquaculture

Z. MARKOVIC, M. STANKOVIC, Z. DULIC, B. RASKOVIC, M. SPASIC, V. POLEKSIC

Faculty of Agriculture, University of Belgrade, Serbia.

Carp production in Serbia is carried out in ponds and cage systems. Total area under carp fish farms is between 13,500 and 14,000 ha, 20 % from that area being neglected and out of use. There are 10 cage systems. Total production of carp and accompanying species: grass carp, big head, silver carp, and predators: pike perch and catfish in 2010 is estimated at about 13,000 t, from that 10,000 t of carp. From the total quantity of carp approximately 70 % is market size. The most commonly practiced system of carp culture is semi intensive (95%), in ponds.

Actual production is twice that from five years ago, and 2.7 times higher than production in 2001, when 3.764 t of carp was produced. Production increase in Serbia is a consequence of changes that occurred in the last decade. From 2003 the biggest carp farms have changed ownership in the privatisation process. As a consequence on some farms that operated with minimum capacity because of lack of working capital a recovery of production occurred. New owners improved farm management and established cost-effective production.

An extremely important effect on production increase was the introduction of complete feed in a semi intensive production system. Till year 2005 as additional food in carp production cereals were almost exclusively used (corn, wheat, barley). With the use of cereals, production per ha is from ~ 500 kg to over 1,000 kg, 700 kg/ha on average. By introducing

extruded feed, primarily in periods of lack of natural food, production increased to 1,500 kg/ha till over 2,500 kg/ha, 2000 kg on average. Last year, 2009, 10,000 t of complete feed was used in Serbia, meaning that more than 50 % of total carp production was achieved by the use of extruded feed.

Enhancement of production using extruded feed is a consequence of relationship established between following factors: researchers – producers of fish feed – carp producers. Formulated feed was tested in experimental conditions prior to its application in the production process on farms. Good results obtained affected gradual increase of production and consequently an increase of adepts of this feeding practice.

Parallel with development of carp production technologies, based on combining natural food and complete extruded feed, in 2007 a family selective breeding program was established. By selective breeding an additional improvement of production of carp, the most important fish species in Serbia will be achieved.

Keywords: carp, Serbia, production

P-010

Recirculation Aquaculture: new FAO/EUROFISH guide-book

THOMAS MOTH-POULSEN

FAO Fisheries Officer for Central and Eastern Europe.

The fast expanding use of the aquaculture water recirculation technique is setting new standards for environmental friendly and sustainable Aquaculture. FAO in cooperation with EUROFISH have made a practical guide book after the KISS principle by one of the worlds leading technical and hands-on experts on the technique.

The strong environmental restrictions to minimise pollution from hatcheries and aquaculture plants in Northern European countries have sparked a rapid technological development of the recirculation technique. The recirculation technique also secure a higher and more stable aquaculture production with less diseases and better ways to control hatchery parameters that influence growth. This development is welcomed and fully in line with FAO's Code of Conduct for Responsible Fisheries. The present guideline on recirculation aquaculture supplements the environmental sustainable aquaculture work of FAO's Subregional Office for Central and Eastern Europe.

The water recirculation technique also implies that hatcheries no longer necessarily need to be placed in pristine areas near rivers. Now they can be built almost anywhere where a much smaller source of clean germ free water is available. It has therefore been a

pleasure for FAO to support the production of this guide which we hope can inspire and help aquaculture farmers adopt the recirculation technique in the future.

The guide book was published in English in January 2010 and will be translated to Russian, Estonian and Lithuanian. The book will form the basis for a series of FAO training workshops in Central- and Eastern Europe and special free downloads will be available on the web.

P-011

Historical presence of wild stocks and recent development of sturgeon farming in Greece: A brief review

Ioannis Paschos, Costas Perdikaris, Evangelia Gouva, Anna Ergolavou

Dept Aquaculture & Fisheries, Technological Educational Institute of Epirus, Irinis & Filias 1, 46100 Igoumenitsa, Greece. Email: cperdik74@yahoo.gr.

Sturgeons were practically unknown in Greece. Populations of stellate sturgeon (*Acipenser stellatus* Pallas, 1771), Adriatic sturgeon (*Acipenser naccarii* Bonaparte, 1836) and beluga sturgeon (*Huso huso* L., 1758) gradually collapsed by the end of the 1970's. Only the River Evros (Thrace, N.W. Greece) sustained a small fishery and caviar canning operation with European sturgeon (*A. sturio* L., 1758) until 1975. Collapse of stocks was attributed to pollution, damming and overfishing. Sturgeons became widely known after the initial farming efforts by the Municipal Hatchery at Lake Ioannina in 1992. Broodstock or fertilised eggs of sterlet (*Acipenser ruthenus* L., 1758), Russian sturgeon (*Acipenser gueldenstaedtii* Brandt, 1833), bester hybrid (*A. ruthenus* x *H. huso*), paddlefish (*Polyodon spathula* Walbaum, 1792), Siberian sturgeon (*Acipenser baerii* Brandt, 1869) and white sturgeon (*Acipenser transmontanus* Richardson, 1836) were imported to Greece between 1992 and 2004. The aim of the present work is to briefly review past the historical presence of wild stocks, restocking efforts, as well as sturgeon hatchery technology, larval rearing and on-growing systems in Greece.

Indigenous freshwater fish and crayfish farming in Greece: Current status and future prospects

COSTAS PERDIKARIS, EVANGELIA GOUVA, LOANNIS PASCHOS

Dept Aquaculture & Fisheries, Technological Educational Institute of Epirus, Irinis & Filias 1, 46100 Igoumenitsa, Greece. Email: cperdik74@yahoo.gr.

The Greek freshwater aquaculture sector is largely dominated by the alien rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792). Other groups of species account for minor production volumes and apart from common carp (*Cyprinus carpio* L.) most of them are of alien origin. Therefore, absence of species diversification, the presence of alien species which in many cases have impacted aquatic biodiversity and emerging consumer attitudes towards environmentally-sound aquaculture practices require thorough re-evaluation of the aquaculture potential of native species. This trend is particularly evident in Eastern Europe and Asia where native species (particularly cyprinids) dominate the production. The current review deals with past and present efforts in the farming of native fish and crayfish species in Greek freshwaters and briefly discusses development opportunities.

Integrated rice–fish farming system in the West African sub-region: The Nigerian model

A. RAJI, C.T. MADU, J. NNAJI

National Institute for Freshwater Fisheries Research, P. M. B. 6006, New Bussa, Nigeria, W. Africa. Email: niffish@yahoo.com.

Nigeria is the leading country in aquaculture production in the West African sub-region with more than 85 per cent of the total fish production in the sub-region. Rice-fish farming is a popular aquaculture production system especially in flood plains/wetlands and the most widely practiced integrated fish farming system in Nigeria.

The authors present in articulated and annotated graphic posters, the popular model of integrated fish farming system in Nigeria. Pond design with fish refuge, fish species and stocking density, popularly accepted long duration rice variety, weed control technique are presented.

Cost-benefit analysis of yields, advantages and disadvantages of the farming system are also highlighted. Integrated rice-fish farming for multiple resource management and

optimisation, diversified revenue earning for additional income and risk reduction, poverty reduction, improved health status and livelihood are emphasised.

P-014

Operation of a privately-owned prawn farm in Cebu, Philippines: Lessons learned from a microcosm of the industry's three decades of experience

LAURO CIPRIANO R. SILAPAN, JR¹, JUDITH R. SILAPAN²

1. University of San Carlos, Cebu City 6000 Philippines; 2. UP in the Visayas, Cebu College Gorordo Ave. Cebu City 6000 Philippines. Email: laryans@yahoo.com.

An aquaculture farm (37 ha, 48 earthen ponds each averaging 0.80 ha) in western Cebu, Philippines started its prawn growing operation in 1986. The farm originally built for semi-intensive culture of prawns involved medium range stocking, use of formulated feeds, mechanical aerators, pumps and in its earlier phase of operation, a closed-pipe system for water distribution.

From 1986-1988 stocking density ranged from 15-20 pieces/m² and productivity from 4.5 to 5.21 mt/ha. With increase in pond utilisation, total annual production rose from 44 to 305 t. This resulted in culture problems aggravated by inclement weather and inconsistent fry quality. With pond utilisation at its peak, survival rates and feed conversion ratio deteriorated. By 1989, total production dropped by 65% compared to the previous year, with disease outbreak experienced not only at the farm level, but industry wide. With the premise that continuous use of ponds at high utilisation rate led to declining productivity even at semi-intensive level, the farm ventured into low density culture in 1992-1993 by growing jumbo prawns for live export. Although it meant lower ecological footprint, production and revenue targets were not achieved, and the failure was attributed to insufficient know-how and skill particularly on live shipment. In 1994-1995, a new shrimp culture technology was introduced in the Philippines and the farm implemented intensive culture (27 pieces/m²). Unfortunately, it resulted in more crop failures. From 1996-1999, stocking density was maintained at 15-17 pieces/m². Pond preparation time was longer and pond utilisation rate averaged 50%. The average yield was only 3.2 mt/ha, but production was more consistent and profitable. This was not sustained though due to the effect of an acid spill from a nearby mining firm in 1999 and a drop in production at 70% pond utilisation rate. Disease outbreaks were experienced coupled with very low prices brought about by the September 11 bombing in New York. The farm did not operate from 2002-2005, permitting a long fallow period. From 2005-2010 the closed-pipe was changed to an open-laundry system. Although the density used was at the upper range of semi-intensive stocking (20-30 pieces/m²), a combination of good quality feeds, food additives, water treatment, high usage of supplemental aeration, and pond rotation contributed to good and profitable operation. The more than three decades of the prawn farm operation reflected some of the experiences of the Philippine prawn industry, and lessons learned from it are basis for improving operation. Establishment

of elaborate, expensive but inappropriate structure/support systems is disadvantageous in the long run. Technology must be studied and adopted on a phased approach.

P-015

Tilapia cage farming in Tien Giang, Vietnam: impacts of water quality on production

NGUYEN NGOC BAO TRAM¹, PHU LE VO²

1. Master student at Department of Environmental Management, Faculty of Environment, HCMUT; 2. Department of Environmental Management, Faculty of Environment, HCMUT.

The aquaculture sector has increasingly played an essential role in meeting the global growing demand of food production. Freshwater aquaculture has been commonly practiced in the Mekong Delta region for centuries providing livelihoods to rural poor people, including food supplies, employments and incomes. Due to land limitation, fish cage culture in Vietnamese rural areas has expanded by effectively taking full advantages of available water resources. Tilapia fish cage cultivation in Tien Giang, a province in Vietnam Mekong Delta has contributed significantly to people's livelihoods, food demand and poverty reduction. However, floating fish farms in Tien Giang have been faced with issues and challenges in cultivation practices and the environments. These challenges include water pollution, diseases and inappropriate practices. This has resulted in an increase in fish deaths over the past 3 years.

A study was carried out in Thoi Son Islet (located in the Tien River, which is close to My Tho City) from September 2009 to June 2010 in an effort to identify impacts of water quality on tilapia farming production. At the study area, a number of surveys, field investigations and water quality tests have been conducted over the last 6 months.

The initial results show that water source at the Thoi Son Islet is likely to be contaminated with organic matters and microorganism due to high concentrations of BOD₅, COD, phosphorus, nitrogen and total coliform. Possible pollution sources can be identified as upstream sources and industrial wastes discharging into the Tien River from My Tho Industrial Park. Furthermore, urban domestic wastewater and agricultural wastes (live stock farms) at the Thoi Son itself are additional sources of water degradation.

Cage aquaculture is a worldwide acknowledged option to overcome challenges in global growing demand of food production and the limits of land availability. Safe and clean water environments will obviously underpin the sustainability of tilapia cage farming in Tien Giang, which has created rural employments and livelihoods of local people.

Artificial propagation of gattan (*Barbus xanthopterus* Heckel) in Basrah, Iraq

MUSTAFA A. AL MUKHTAR¹, JASIM H.A.A. JABER¹, FALEH M. ALZAIDI¹, AUDA M. HASSAN¹, KHALID H. HUSSONI¹, SAJAD A., NASIR H. AL SHAWEI²

1. Marine Science Center; 2. Agriculture Directorate.

Gattan (*Barbus xanthopterus* Heckel) was artificially propagated in the marine science center fish hatchery - University of Basrah, during spring 2009. The brooders were collected from Al Huwaizah Marsh (and brought to the hatchery directly) and Al Therthar reservoir (which were reared in earthen ponds). The efforts to collect brooders from Al Kut dam failed, because of water shortage. The brooders ranged between 1500-6,500 g in weight and II-V years age. The gonads of Al Huwaizah marsh brooders were in good maturity stage, and the GSI ranged between 3.66 and 11.03 in ripe fish. The gonads of brooders from Al Therthar reservoir were in a developing stage, with GSI ranging between 1.1-1.3. "Aquacalm" substance was used for sedation, it was found that the best concentration for the sedation of Gattan was 1 ppm. The best treatment for the induced spawning of Gattan was the carp pituitary gland Extract (CPG), at a dosage of 6mg/kg, in two equal injections at 12 hour interval. Two fishes of 1,750 and 1,500g from Al Therthar reservoir responded to this treatment and 350 g of good quality eggs were obtained from one fish. All the males had a small quantity of milt. The milt was added to the eggs without water for mixing. Then the eggs were covered with water. Fertilisation rate was 88%. The fertilised eggs washed with water only, from brooders rearing tank for 20min, then incubated in Zoug jars with at a rate off 70g/jar; incubation temperature ranged between 22-24 °C. The hatching completed after 72 hours with 80% hatching rate. The larvae started feeding after three days, and reached a weight of 5.3 ± 0.80 mg during the first ten days. The larvae were reared in floating cages. The daily growth was 1.94mg during the 21 days of rearing. During this period it reached a weight of 48mg and 23mm in length.

Ovarian morphohistology of Caspian Sea narrow-clawed crayfish *Astacus leptodactylus* during development

FOROUZANDEH ELAHEH, HEIDARI BEHROOZ

Department of Biology, Faculty of Science, Guilan University, Rasht, Iran.

Email: forouzandeh12@gmail.com.

In this study, ovarian morphohistology of Caspian sea narrow-clawed crayfish (*Astacus leptodactylus*) including external observation of ovaries, changes in the gonadosomatic index (GSI) and the histological analysis of the females ovaries were investigated. Narrow-

clawed crayfish is an economically important Astacid species of the Caspian Sea that is used as live food. The animals were captured from Southern Caspian Sea (Guilan Province, Iran) and then transferred in ice to the laboratory. The animals were kept in 400-, 40- and 50-l freshwater tanks at 24 ± 1 °C with a photoperiod of 14D:10L. Animals were fed earthworms.

Ovarian development in the narrow-clawed crayfish is divided into three major phases, namely primary- and secondary-vitellogenesis and maturation. Primary-vitellogenesis included early perinuclear zone- and late perinuclear zone stages and secondary vitellogenesis contains previtellogenic and vitellogenic stages.

Keywords: morphology, Astacus leptodactylus , gonadosomatic index, histology, vitellogenesis

P-018

Comparison on larval survival and growth of tiger grouper, *Epinephelus fuscoguttatus* at different first feeding

CHING FUI FUI¹, YOSHIZUMI NAKAGAWA¹, KEITARO KATO¹, OSAMU MURATA¹, SHIGEHARU SENOO², SHIGERU MIYASHITA¹

1. Fisheries Laboratory, Kinki University, 3153, Shirahama, Wakayama 649-2211, Japan; 2. Borneo Marine Research Institute, University Malaysia Sabah, 88999, Kota Kinabalu, Sabah, Malaysia.

Tiger grouper, *Epinephelus fuscoguttatus* is an economically important aquaculture species in the Southeast Asian region. A restriction to its stable industry growth is attributed by the insufficient seed supply owing to the high mortality at the early larval stage. Tiger grouper larvae, which possess a small yolk sac and short nutritional transition period (NTP) makes it difficult to commence first feeding successfully, when larvae switch from endogenous to exogenous feeding. The point of no return (PNR) is used to measure the degree of larval ability to withstand starvation. To enhance survival and growth at the early larval stage, PNR and the comparison on larval survival and growth of tiger grouper fed in different first feeding time were studied.

Fifteen of 7L plastic aquariums were divided into three groups as triplicate. The larval stocking density was 50 individuals/l. The first exogenous feed intake of the larvae was observed at 54 hrs after hatched (hAH) at 28 °C. The time at which the experiment commenced was defined as 0 hours delayed first feeding (hDFF). Rotifer, *Brachinosis* spp. complex and *Nannochloropsis* spp. were introduced at first feeding at a density of 50 ind/ml and 0.5 million cells/ml, respectively. The first feedings were delayed for every 6 hour intervals up to 24 hours DFF. The larval survival and growth were observed throughout the experimental period at 6 hourly intervals. PNR was determined by visual analysis of a larval

survival curve, when less than 50% starved larvae survived but were unable to commence feeding even feed was made available. The experiment was conducted for 15 days.

The highest survival rate (21.0%) and mean total length (8.10 ± 0.21 mm) were observed in 0 hours DFF. In contrast, the larvae of 6 and 12 hours DFF showed a comparatively lower larval survival (90.6% and 72.0%) and growth (4.53 ± 0.35 mm, 2.60 ± 0.1 mm). First larval mortality occurred at 72 hours AH observed in 18 and 24 hour DFF treatments. The PNR was observed in 66 hour AH. This study indicates that delayed first feeding time had resulted in higher mortality and lower growth of the larvae. We recommend that tiger grouper must commence first feeding immediately at the beginning of the NTP (54 hour AH) at 28 °C. We conclude that delayed first feeding time was harmful for survival and growth of tiger grouper.

P-019

Effects of hatching timing on larval survival and deformity of native marble goby, *Oxyeleotris marmoratus* (Sabah, Malaysia)

NGUANG SIEW ING¹, YOSHIZUMI NAKAGAWA¹, KEITARO KATO¹, OSAMU MURATA¹, SHIGEHARU SENOO², SHIGERU MIYASHITA¹

1. Shirahama Experimental Station, Fisheries Laboratory of Kinki University, Japan; 2. Borneo Marine Research Institute, Universiti Malaysia Sabah, Malaysia.

The marble goby, *Oxyeleotris marmoratus* is a freshwater member of the Eleotridae that grows up to more than 50 cm in total length and 2 kg in body weight. The price is one of the highest in freshwater table fishes in Southeast Asia. A retail price of US\$25-30/kg in Malaysia is nearly 10-30 times higher than the other common freshwater table fishes. This fish is distributed in whole of Southeast Asian region and it is considered that there are several strains. Early larval survival is inconsistent due to high mortality just after hatching. To improve the seed production technique for *O. marmoratus* in Sabah, Malaysia, the egg development and hatching were observed under artificial incubating conditions.

Twenty thousand fertilised eggs were deposited on a rectangular wooden-framed plankton net (30x40 cm) with 250 µm mesh size. The eggs dangling from the net were incubated in an aquarium tank (100 x 45 x 45 cm). The developmental stages of eggs were observed until hatched. Hatching condition was observed in every 24 hours (0-24, 24-48, 48-72, 72-96, 96-120 and 120-144 hours after fertilisation). The hatched larvae were transferred and reared in a transparent tank containing 7 L of 10 ppt water. Larval survival was counted at 10 days after fertilisation.

The egg development and hatching condition of *O. marmoratus* were very similar to those of the native *O. marmoratus* in Peninsular Malaysia. In comparison with the other gobies, native *O. marmoratus* have 1) small and many eggs, 2) all the eggs were developing with

agrippa condition, 3) hatchings occurred at different developmental stages such as before eye pigmentation or after eye pigmentation. Those three features were deeply correlated to each other and considered very important factors for larval survival in nature. The highest hatching and survival of the larvae were observed during 48-72 hours after fertilisation. Larval deformation increased after 96 hours after fertilisation and over developed eggs were not able to hatch after 120 hours post fertilisation.

P-020

Application of nanosilver filters in egg incubation system of rainbow trout (*Oncorhynchus mykiss*)

SAYED ALI JOHARI¹, MOHAMMAD REZA KALBASSI¹, MEHDI SOLTANI²

1. Department of Fisheries Sciences, Faculty of Marine Sciences, Tarbiat Modares University, Tehran, Iran. 2. Department of Aquatic Animal Health, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran. Email: sajarahari@gmail.com.

Nanotechnology is emerging as a rapidly growing field with its application in science and technology. Silver nanoparticles have proved to be most effective as it has good antimicrobial efficacy against bacteria, viruses and other eukaryotic micro-organisms. Unfortunately attention to potentials of this new technology in aquaculture industry is unaddressed.

In this study indirect use of silver nanoparticles was investigated for reduction of eggs fungal infections during incubation period of rainbow trout (*Oncorhynchus mykiss*). Nanosilver-coated clinoptilolite was compared with unmodified clinoptilolite as filter media in two separate recirculation systems. Whole water of each incubator was circulated through out the filter media and again backed to incubator. In baskets of each incubator 2,000 newly fertilised eggs were put. The water of each incubator was infected by introduction of water mould-infected eggs periodically. Water temperature and chemistry were routinely monitored and maintained constant over the entire incubation period. Dead and infected eggs and embryos were periodically removed and survival rates were expressed as percentages of the initial number of eggs used for fertilisation. To confirm valid coating of silver nanoparticles on clinoptilolite properties of coated materials were investigated using FTIR, XRD, XRF, and SEM methods.

Percentages of survival from fertilisation to eyed-stage in nanosilver-coated and uncoated clinoptilolite were 60.42 and 67.20 respectively. Hatching rates were 56.33% and 60.39% respectively. Percentage of survival from hatching to swim up stage was 96.94 and 97.99 respectively. Totally, percentages of survival from fertilisation to swim up stage were 54.60 and 59.17 in nanosilver-coated and uncoated clinoptilolite, respectively. No fungal infections were observed during the incubation period in incubators which have nanosilver-coated filters. The percentage of malformations of produced fish wasn't significantly

differing between two treatments. From the results, it has emerged that using nanosilver filters is significantly effective for prevention from fungal infections and therewith to increase propagation output. Also we are doing more investigations about release of silver nanoparticles from these filters and probable undesirable effects on produced fishes and bioaccumulation of silver nanoparticles in those fishes.

P-021

Sexual separation and photothermal manipulation aids prolonged ovarian recrudescence and delayed spawning induction in the Indian catfish, *Heteropneustes fossilis* (Bloch)

RAMANATHAN KOTEESWARAN, THAVAMANI JEGAJOTHIVEL PANDIAN

Department of Genetics, Centre for Advanced Studies in Functional Genomics, School of Biological Sciences, Madurai Kamaraj University, Madurai – 625 021, Tamilnadu, India. Email: keshwaran@yahoo.co.in.

The Indian catfish, *Heteropneustes fossilis* is an economically important annual spawner spawning between July to August. In the present study an attempt was made to delay the spawning by combining sexual separation and photothermal treatment, as circannual rhythm of gonadal regression has been demonstrated in this fish. Healthy male and female spawners ($90 \pm 20\text{g}$) procured from Tiruchirapalli (1996-97), Palayamkottai (1997-98) and Nagerkoil (1998-99) during June every year were separately maintained at a constant photoperiod (18 L/6 D) and temperature ($28 \pm 2^\circ\text{C}$) throughout the experiment.

Spawning was induced during September to January every year by administering a single dose of ovaprim intramuscularly (0.5 ml/kg to females and 0.3 ml/kg to males). There was a slight decrease in egg size ($0.23 \pm 0.11\text{mm}$), fecundity (998.6 ± 163.45), fertilisation rate ($15.9 \pm 5.27\%$) and hatching rate ($8.1 \pm 2.72\%$) associated with increase in frequency of deformity ($17.1 \pm 2.38\%$) during January compared to controls (July–August) during the 3 year experiment. Caudal deformities (ventral and dorsal bents) were more frequent among the deformed hatchlings.

The present study demonstrates: a) the combined effects of sexual separation and photothermal treatment to override the circannual rhythm of gonadal regression in *H. fossilis*, and b) the applicability of this technique to different stocks of *H. fossilis*. Secondly, normal healthy seeds can be obtained for culture during “off-season” also.

Keywords: *Heteropneustes fossilis*, sexual separation, photothermal manipulation, ovarian recrudescence, delayed spawning

Breeding technology for the production of fingerlings of the indigenous catfish, *Heterobranchus longifilis* in Nigeria, West Africa

C.T. MADU, A. RAJI

National Institute for Freshwater Fisheries Research, P. M. B. 6006, New Bussa, Nigeria, W. Africa. Email: maduchuka@yahoo.com.

Heterobranchus longifilis (Valenciennes, 1840) is a very much cherished and commonly cultured indigenous catfish in Nigeria, often used as gifts at marriages and other ceremonial occasions. However, the scarcity of its fingerlings to meet the demand of fish farmers is a major problem in Nigeria. This poster presentation illustrates some improved step-wise techniques for the year-round production of the fingerlings. These include: (a) choice of healthy brooders above one kg in weight and the pairing of males and females from different parental origins for induced breeding to avoid in-breeding depressions, (b) injecting the selected males and females with active gonadotropic hormone and stripping the eggs after 11-12 hours latency period, (c) use of mechanical aerators for egg incubation and indoor nursery management of hatchlings, (d) local production of indigenous natural food (zooplankton) and utilisation as first food of fry, (e) fortnightly sampling of nursery tanks/ ponds to prevent cannibalism resulting from differential growth of fry. For year-round gonadal development and fingerling production in the dry northern zones of the country, rainfall and flooding are simulated in brood stock tanks twice a week. Over 85 percent survival of fingerlings is achieved based on this technology and culture period is 6-7 weeks. Annotated graphics and photographs are used to illustrate various aspects of the technology.

Broodstock management of the humpback grouper, *Cromileptes altivelis* (Valenciennes, 1828), based on information on molecular markers

UTHAIRAT NA-NAKORN¹, RENOO YASHIRO², ANYALAK WACHIRACHAIKARN³, WARANGKANA PRAKOOK¹, NIPON PANSANEN²

1. Department of Aquaculture, Faculty of Fisheries, Kasetsart University, Chatuchak, Bangkok 10900, Thailand; 2. Department of Fisheries, Ministry of Agriculture and Cooperatives, Bangkok, Thailand; 3. Interdisciplinary Program in Genetic Engineering, Graduate School, Kasetsart University, Bangkok, Thailand. Email: uthairatn@yahoo.com.

Artificial breeding of the humpback grouper, *Cromileptes altivelis* (Valenciennes, 1828) was performed either with or without hormone injection and the brooders were allowed to communally spawn. This raised concerns on reduction of effective population size

by various factors related to the communal spawning. In the present study the first sets of microsatellite primers for two panels of multiplex PCRs (triplex and pentaplex) were developed from DNA of *C. altivelis* and employed for parentage analysis and evaluation of genetic variation of three stocks, a parental stock (P, n = 20); the first generation offspring (G1, n = 120, age = 4 months); and an unrelated potential broodstock (PP, n = 118). The parentage analysis showed that among 20 brooders (P), two females and five males contributed to genetic composition of the G1. We observed multiple paternity, wherein each of the female mated with two or three males. Moreover, the family contribution was skewed and the G1 was dominated with a single full-sib (87.50%). These factors likely resulted in low effective population size and may enhance inbreeding in the successive generations. Genetic variation was studied based on seven loci (a locus was removed from the analysis due to physical linkage) and showed that the potential broodstock had slightly low genetic variation relative to the parental stock. However, genetic distance and genetic relatedness estimator (rxy) indicated that the stock was sufficiently diverse from the parental stock. As such, it may be used as female parents for P which will be dominated by males as the stock grows older. However, due to high rxy between some pairs of P and PP, the breeding pairs should be carefully selected base on low genetic relatedness to avoid inbreeding.

P-024

Potential application of new technologies in selective breeding programs for aquaculture species

NGUYEN HONG NGUYEN, RAUL W. PONZONI

The WorldFish Center, Penang, Malaysia. Email: n.nguyen@cgiar.org.

In this paper we discuss some potential applications of molecular genetics and reproductive technologies that can potentially enhance the efficiency of breeding improvement programs in farmed aquaculture species. We focus on four techniques of molecular genetics (identification of candidate populations using DNA markers, genetic tagging, marker assisted selection and genomic selection) and two reproduction technologies (in-vitro fertilisation and sperm cryopreservation). First, genetic characterisation of strains using DNA markers can be used to identify genetically distinct populations before establishing a base population for the later conduct of a genetic improvement program. Identification of distinct stocks to be included in the breeding programs can result in abundant genetic variation to ensure future genetic gains. Second, DNA fingerprinting applied for parentage testing and pedigree verification provides four main advantages: increasing number of families tested without the need to increase the number of tanks and ponds, reducing the effect common to full-sibs, shortening generation interval, minimising interaction between the selection and production environments, and consequently increasing genetic gain. Both experimental and theoretical results show that with the availability of microsatellite markers, pedigree analysis can give very high degree of accuracy across aquatic species. The posterior assignment of parents and tracking of family origin allows pooling all families

from incubation, thus enabling, communal testing very soon after hatching, eliminating common environmental effects and increasing genetic gain relative to the conventional approach of separate rearing of individual family until the fish reach a suitable size to be physically tagged. Third, gene- or marker-assisted selection (MAS) is particularly useful for traits which are difficult to measure (e.g. flesh quality, disease resistance) and for traits with low heritability (fitness related traits). With the current stage of development there are both technical and economic limitations in order to effectively apply MAS in breeding programs for tilapias and carps. Fourth, recent developments unveiling thousands of single nucleotide polymorphisms (SNPs) and the reduced cost of genotyping per SNP open possibilities for genomic selection. Genomic selection can increase response by two-fold and reduce the cost of breeding programs, especially in species that have a long cycle of production (long generation interval). The efficiency of genomic selection is generally dependant on the characteristics of the traits in question, on the number of SNPs, linkage disequilibrium between QTL and markers, marker allele frequencies. The approach is being implemented in dairy cattle and chicken, but its potential value in fish is still to be ascertained. With respect to reproductive technologies, in-vitro fertilisation and cryopreservation have two main advantages: allow the design of different mating schemes to increase accuracy of parameter estimation and thus accuracy of selection, reduce inbreeding, and estimate genetic change. In conclusion, molecular genetics and reproductive technologies are potentially beneficial to practical breeding programs, but their application should be judged based on individual cases, especially from an economic perspective.

P-025

Induction of maturation and spawning of jack mackerel (*Trachurus japonicus*) temporarily reared in captivity using GnRH α

MITSUO NYUJIM¹, KAZUKI FUJISAWA¹, HAJIME KITANO¹, AKIHIKO YAMAGUCHI¹, MICHIO YONEDA², AKIO SHIMIZU², MICHIIYA MATSUYAMA¹

1. Laboratory of Marine Biology, Kyushu University, Fukuoka 812-8581, Japan; 2. Fisheries Research Agency, Yokohama 236-8648, Japan. Email: nyuujim@agr.kyushu-u.ac.jp.

The jack mackerel (*Trachurus japonicus*) is a key multiple batch-spawning pelagic fish and is also one of the most commercially important fish species of Japan. Owing to a decline in the wild populations, the concept of total allowable catch was introduced in Japan in 1997 to manage the fishing of wild-stock jack mackerel, as well as for other seven species. Due to unreliable and unpredictable wild catches, aquaculture of jack mackerel commenced recently in southwestern Japan. Young or adult fish are caught from the wild and reared for an appropriate duration in sea cages. However, to enable the sustainable supply of jack mackerel for the market, it is essential to establish a seed production system. To date, there has been no success in a stable seed production of jack mackerel. Our previous studies showed that the majority of wild caught adult females showed atretic oocytes, likely due to fishing stress. Moreover, when we attempted to use the adult fish that had been

reared in the lab for over one year, female fish failed to undergo vitellogenesis, possibly due to the captivity induced stress and other unknown endocrine factors. Therefore, in the present study, we used wild caught jack mackerel temporarily held in captive conditions, for induction of final oocyte maturation (FOM) and ovulation.

Adult fish (fork length >280 mm) were caught by hook and line to avoid any stress. The wild caught fish were temporarily held in captivity and gonadal biopsy was performed using a plastic catheter tube to select fish with developed ovaries. Accordingly, four females with oocyte diameter ranging from 550-660 µm and five spermiating males were used for the experiment. They were injected intramuscularly with GnRH_a (des-Gly10-[D-Ala6] LH-RH ethylamide, 400 µg/kg body weight), suspended in molten cocoa butter and were maintained in a 3-ton tank. The first spawning was observed two days after GnRH_a treatment. Spawning was recorded for 18 consecutive days from first spawning and between 22:00-24:00 h. The number of eggs collected at each spawning was 145,000 on the 1st night, 92,000 on the 2nd night and 4,000-33,000 on the others day. Spawning ended when water temperature reached 23 °C. The mean fertilisation and hatching rate were 39.9% and 81.3%, respectively. This study revealed that fish caught in less stress conditions can be effectively used for induction of spawning by hormonal treatments. In addition, GnRH_a-induced maturation and spawning of group of jack mackerel have the potential to spawn every day. In conclusion, stable seed production of jack mackerel can be achieved in future by the application of this protocol in wild caught fish with vitellogenic ovaries.

P-026

Increasing aquaculture productivity through genetic improvement

RAUL W. PONZONI, NGUYEN HONG NGUYEN, KHAW HOOI LING, KHAIRUL RIZAL ABU BAKAR, HOONG YIP YEE, CURTIS LIND

*The WorldFish Center, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia.
Email: r.ponzoni@cgiar.org.*

In this paper we provide an outline of research programs in quantitative genetics which carried out by the WorldFish Center to improve quality of brood stock and performance of farmed aquaculture species, especially in freshwater fish. A classic success story is the genetically improved farmed tilapia (GIFT), with genetic gains of 10 to 20% per generation of selection. The fish show remarkable vigour and high adaptation to a wide range of farming conditions in Asian countries. There are no differences in flesh quality attributes between GIFT and three local strains of red tilapia in Malaysia. The GIFT technology has been applied to the improvement of native strains of tilapia in African countries (e.g. *Oreochromis shiranus* in Malawi). The second group of species we have focused on is Asian carp fish (common carp, silver barb and rohu). The WorldFish Center has collaborated with six partner countries in Asia to develop improved strains of carps. Across species, genetic gain achieved ranged from 7 to 22% per generation. Before releasing the new strain to

production systems, comparisons with that of local carp stocks were conducted in relevant regions of some of the countries. Across farming systems in Bangladesh, Thailand and Vietnam, the selected carp strains had 20-40% greater growth performance than local stocks of the same species. A phenomenal improvement of the Jayanti rohu carp (up to 117%) relative to the locally available stock was observed in India. Thus, the genetically improved carp strains are being widely adopted and cultured by farmers in Asia. Recently WorldFish has expanded its successful program of breeding genetically improved strains of farmed tilapia and carp to include freshwater prawn *Macrobrachium rosenbergii*, one of the most important crustaceans in inland aquaculture in Asia. Selective breeding programs are at various stages of development in India, Malaysia and Vietnam, where we collaborate with partners possessing the required facilities and skilled personnel. The involvement of the three countries ensures that the project captures their wealth of experience to expand to other Asian countries in the future. In parallel with genetic improvement activities, we have also developed strategies for the effective dissemination of improved strains to farmers and fish producers. Currently, we are broadening the scope of our work in the areas of genetic conservation, risk assessment in relation to the use of improved strains, and resource management and biodiversity. In addition, the WorldFish Center has been placing a strong emphasis on human resource development and capacity building of national aquaculture institutions in the areas of genetics and statistics. It is concluded that genetic improvement has resulted in substantial improvement in the aquaculture productivity and promoting sustainability of the industry.

P-027

Using RAPD markers potential to identify heritability for growth in prawn (*Penaeus indicus*)

REZVANI GILCOLAE, S.¹, SAFARI, R.¹, LALOEI, F.², TAGHAVI, M.J.²

1. Iranian Fisheries Research Organization, Tehran, Iran; 2. Ecology Research Institute of the Caspian Sea, Mazandaran, Iran.

Sampling was done using 90 post larvae which were produced by reproduction of broodstock of *Penaeus indicus* in one day and reared in the same situation for 4 months. Samples were divided into three groups for high, medium and low growth (based on weight and length). Genomic DNA was extracted from muscle tissue using phenol-chloroform method. The polymerase chain reaction (PCR) was carried out using 21 RAPD loci and PCR products were separated on 3% agarose gel. From 21 loci studied, 12 produced polymorphic bands. The most polymorphic band produced using OPAQ 9 and the least by OPAQ 7. Search for specific markers in *P. indicus* 1 specific band was observed in the low- growth group using OPAQ 4. According to Nei (1972), the highest distance (0.457) was between low growth group and medium and the lowest (0.091) between high growth groups and medium, therefore the highest identity (0.912) was between high growth group and medium and the lowest (0.633) between low growth group and medium. Neighbour-joining

tree using Nei (1972) resulted in two clades, the first including high and medium growth groups and the second low growth group. It appears that low growth group depended on separated population of the others. Considering mean weight of F1 (mean weight of 90 specimens) (16.25 ± 1.5 g), parental generation mean weight of 15 ± 1.2 g and mean weight of parent 31.6 g, response to selection (R) and heritability for growth in this species were estimated to be 1.2 ± 0.2 and 0.07 ± 0.01 respectively.

P-028

Expression profiles of three GnRH forms in the brain and pituitary of chub mackerel (*Scomber japonicus*) during ovarian cycle in captivity

SETHU SELVARAJ¹, HAJIME KITANO¹, MASAFUMI AMANO², AKIHIKO YAMAGUCHI¹, MICHIIYA MATSUYAMA¹

1. *Laboratory of Marine Biology, Kyushu University, Fukuoka 812-8581, Japan*; 2. *School of Marine Biosciences, Kitasato University, Iwate 022-0101, Japan.*

The brain-pituitary-gonad (BPG) axis is a key neuroendocrine network responsible for reproduction in vertebrates, including teleosts. In teleosts, gonadotropin-releasing hormone (GnRH) neurons in the brain innervates the pituitary and stimulates secretion of gonadotropins (GtHs), follicle-stimulating hormone (FSH) and luteinising hormone (LH), which in turn stimulates the production of sex steroids in gonads for gametogenesis. Moreover, teleosts express multiple GnRHs in the brain. Considering the critical role played by GnRHs-GtHs-sex steroids in the BPG axis, understanding this key pathway is highly indispensable for sustainable seed production, as female chub mackerel fails to undergo oocyte maturation and spawning in the captivity. Recently, GtHs of chub mackerel were purified from the pituitary and using in vitro bioassays, we showed that FSH and LH are involved in oocyte growth and LH in maturation process. In addition, the brain of chub mackerel expresses three GnRH forms namely, seabream GnRH (sbGnRH), chicken GnRH-II (cGnRH-II) and salmon GnRH (sGnRH), with only sbGnRH-immunoreactive (ir) axonal fibers innervating the pituitary, targeting FSH and LH-producing cells. However, GnRH form responsible for reproductive function in this scombroid fish is still unclear. Hence, in the present study using real-time PCR and time-resolved fluoroimmunoassay, we investigated their quantitative changes in the messenger RNA (mRNA) and peptide levels in the brain and pituitary of adult fish undergoing ovarian cycle in captivity. The ovarian stages analysed were immature (IM), early vitellogenesis (EV), late vitellogenesis (LV) and post-spawning (PS).

Results showed that the levels of sbGnRH mRNA and peptide in the brain gradually increased from IM to LV stage and significantly peaked during PS stage. The peptide levels in the pituitary significantly increased from IM to LV stage and remained high in PS stage. In contrast, levels of cGnRH-II and sGnRH mRNA in the brain showed no variation. Moreover, sGnRH peptide levels in the brain and pituitary increased from IM to LV stage and IM to PS stage, respectively. Overall, sbGnRH peptide levels in the pituitary correlated well with the

progress of vitellogenesis, suggesting the possibility of involvement in the stimulation and release of GtHs for ovarian growth.

In conclusion, the present study suggests that sbGnRH is the dominant form involved in the ovarian cycle of chub mackerel in captivity. In addition, we speculate that sGnRH may exert reproductive role in this scombroid fish, as indicated by the fluctuations in the peptide levels in the brain and pituitary during different reproductive stages. The present experimental rearing system of chub mackerel provides an excellent platform for undertaking endocrinological studies in future that will deepen our understanding of BPG axis in teleosts.

P-029

Gene expression analyses in Japanese medaka (*Oryzias latipes*) exposed to alkalinity stress

ZONG LI YAO^{1,2}, QI FANG LAI¹, LING CHEN², KAI ZHOU¹, HUI WANG¹, CHENG QI YING

1. East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Key and Open Laboratory of Marine and Estuarine Fisheries, Ministry of Agriculture, Shanghai, 200090, China; 2. State Key Laboratory of Pollution Control and Resource Reuse, College of Environmental Science and Engineering, Tongji University, Shanghai 200092, China.

Alkalinity stress is common in cultured aquatic animals and considered to be one of the major stress factors for fishes when they are transferred to saline-alkali waters. Thus, understanding the molecular genetic response to alkalinity stress by model aquatic organisms is of interest both from aquaculture and physiological viewpoint. The major objectives of this study are to determine genome-wide gene expression profiles and to better understand how carbonate alkalinity stress influences global gene expression in medaka (*Oryzias latipes*), a model vertebrate for developmental and evolutionary biology studies. We detail our development of a microarray containing 27,809 oligonucleotides and describe our experimental results for measuring gene expression changes in gill and kidney of CA stress exposed fish. Using SAM and T-test methods, we determined that 2,769 genes in gill and 2,516 genes in kidney which were differentially expressed in medaka exposed to CA stress. These differentially expressed genes group into a number of biological gene ontology groups related to developmental process, reproduction, immune system process, metabolic process, transcription regulator activity, enzyme regulation activity, transporter activity etc. Biological pathways GnRH signalling pathway, regulation of gene expression in endocrine, HIF-2-alpha transcription factor network in gills and HIF-1-alpha transcription factor network, hypoxic and oxygen homeostasis regulation and direct p53 effectors etc. were significantly regulated.

Behavioural alterations explain increased competitive feeding ability in growth- enhanced transgenic common carp

TANGLIN ZHANG, MING DUAN, WEI HU, TINGBING ZHU, ZHONGJIE LI, ZUOYAN ZHU

State Key Laboratory of Freshwater Ecology and Biotechnology, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, P. R. China. Email: tlzhang@ihb.ac.cn.

Growth hormone (GH) transgenic fish possess a higher growth rate and are of great commercial interest in aquaculture, but also raise concerns on the potential impacts of escaped or released transgenic fish on aquatic ecosystems. To predict environmental risks, it is crucial to obtain information on the relative fitness of GH-transgenic fish. Previous studies revealed that increased GH levels in GH-transgenic common carp (*Cyprinus carpio* L.) increase ability to compete for artificial feed than non-transgenic fish. This study further explores behavioural mechanism of the increased feeding ability in the transgenic fish. The transgenic strain of common carp used contained a gene construct (pCAgcGH) consisting of grass carp (*Ctenopharyngodon idellus*) growth hormone (gcGH) driven by the common carp β -actin gene promoter (pCA). The transgenic fish (mean size = 4.2 g) were F4 individuals. In six consecutive feeding trials, pellets were provided sequentially and the identity of the fish taking each pellet was noted. The number of movements, dominance index (calculated from aggression data) and intake of contested food pellets by 14 size-matched pairs consisting of one control and one GH-transgenic fish were measured. The transgenic fish exhibited 2.1 times more movements and showed a higher dominance index relative to their controls in feeding period (10 minutes). Also, similar cases occurred in both before- and after-feeding periods (2 minutes). Calculated on the total of 20 pellets offered at each feeding trial, the transgenic fish consumed 74% more pellets than the controls. During the overall experiment, the specific growth rate of the transgenic fish was 3.1 (in weight) and 1.0 (in length) times higher than the non-transgenic fish. These results show that GH transgenesis alters behaviours in juvenile common carp and thereby, behavioural alterations may explain elevated competitive feeding ability in GH-transgenic common carp. In addition, the present study suggests that escaped GH-transgenic fish could be advantageous in the wild, which will depend on how transgenic and wild individuals differ in other fitness-related characters.

Keywords: foraging, behaviour, competition, growth hormone, transgene.

Genetic population structure of hawksbill (*Eretmochelys imbricata*) using microsatellite analysis

HOSSEIN ZOLGHARNEIN, MOHAMMAD ALI SALARI ALIABADI, SOMAYEH ROSHANI

Department of Marine Biology, Faculty of Marine Science, Khorramshahr University of Marine Science and Technology, Khorramshahr, Khuzestan, Iran.

Email: zolgharnine@yahoo.com.

Information on the genetic structure of marine species is essential for optimising fisheries management and stock improvement programs. In pursuance of Hawksbill turtle (*Eretmochelys imbricata*) genetic diversity in Kish and Qeshm Island by Microsatellite genetic method, 64 samples were caught from them beaches. Separated 2-5 grams of internal tissue, fixed in absolute ethanol (96%) and transported to Khorramshahr University of Marine Science and Technology's biotechnology Lab. DNA was extracted according to phenol-chloroform method then quality and quantity tested by electrophorus and spectrophotometer respectively. Polymerase chain reactions were done using 5 pair of microsatellite primers. polyacrilamid and silver nitrate used for dyeing of PCR production afterwards run using electrophorus and take picture by gel document. According to result, all 5 pairs of microsatellite primer were polymorphic. Average number of real allele and effective allele were 4.90 and 2.989 respectively. Average rate of observed heterozygosity was 0.570 and 0.616 for expected heterozygosity. Study of Hardy-Weinberg equilibrium shown all loci did not have equilibrium except Cm3 and Ei8 locus in Kish area. F_{st} (0.166) and R_{st} (0.634) calculated by AMOVA test illustrated there are separate populations of Hawksbill turtle in this part of Persian Gulf (Kish and Qeshm islands). It seems that Kish's turtles have better condition in contrast to Qeshm's. Decrease of genetic difference lead to decline genetic potential and diminution of adaptation to environmental changes. So it is necessary to monitor variation in population genetic structure. The present study showed that at least two different populations of *E. imbricata* were found in the northern coasts of Persian Gulf.

Keywords: Microsatellites; genetic variation; polymorphism; Eretmochelys imbricata, Persian Gulf.

The study of physiological aspects of Caspian kutum (*Rutilus frisii kutum*, Kamensky 1901) oocyte during ovarian growth in the Southern Caspian Sea

HEIDARI BEHROOZ¹, SAVARI AHMAD², SHABANIPOUR NADER¹, YAVARI VAHID²

1. Department of Biology, Faculty of Science, Guilan University, Rasht, Iran; 2. Department of Marine Biology, Faculty of Marine Science and Oceanography, Khoramshahr Marine Science and Technology University, Iran. Email: bheidari@guilan.ac.ir.

In this study, physiological aspects of Caspian kutum (*Rutilus frisii kutum*, Kamensky, 1901) oocyte including measurement of plasma levels of sexual hormones (17 β -estradiol, testosterone, progesterone, 17 α -hydroxyprogesterone), plasma cations, osmolarity and plasma total protein were analysed in two different ecological medium, Southern Caspian Sea and its rivers.

Kutum is an economically important anadromous endemic cyprinid species of Caspian Sea that enter to the rivers for spawning. Adult Kutum were captured approximately monthly from the Anzali shore of the Southern Caspian Sea (37° 27' N, 49° 33' E) (Guilan Province, Iran) using beach seines. Maturing and migratory fish were captured from the Sefid Rood River inlets to the Caspian Sea during the spawning migration in April–May 2008. Plasma levels of hormones were determined using radioimmunoassay (RIA) after extraction. The measurements of Na⁺, K⁺, Ca⁺⁺ were achieved by digital flame photometer (model; 310C) and the total protein was measured by Bradford method.

The plasma levels of sexual hormones during ovarian growth indicated increasing trend of 17 β -estradiol and testosterone, which continued until the end of vitellogenesis stage within the Sea and then their levels decreased in maturation phase. In turn, the plasma levels of progesterone and 17 α -hydroxyprogesterone increased until spawning within the rivers in maturation phase and decreased afterwards. The maximum levels of 17 β -estradiol and testosterone were measured in March sampling coinciding with the end of vitellogenesis (133.43 \pm 19.69 and 6.99 \pm 1.44 ng/ml respectively) but the maximum value of progesterone and 17 α -hydroxyprogesterone levels was observed in April sampling that is the time of oocyte maturation (2.60 \pm 0.37 and 4.02 \pm 2.25 ng/ml respectively). The values of Na⁺, K⁺ and Ca⁺⁺ as well as osmolarity at different stages of oocyte development showed two ions Na⁺ and Ca⁺⁺ did not undergo more changes until the early maturation (3 April) (P>0.05) but at the final oocyte maturation (15 April), these cations significantly diminished (P<0.05). The potassium ion showed the same trend from late March concurrent with anadromic migration. The plasma osmolarity that depends on Na⁺ and K⁺ ions, follow the same trend of K⁺. The concentration of total plasma protein showed that there was not significant variations at more developmental stages of oocyte (P>0.05) only, after final maturation and spent stages was observed significant difference (P<0.05). In addition, strong positive correlation (R=0.88) was recorded between Ca⁺⁺ and plasma protein.

In conclusion, it seems that 17β -estradiol and 17α -hydroxyprogesterone are responsible for the vitellogenesis and maturation of kutum oocyte, respectively. In addition, Na^+ and K^+ not Ca^{++} play the main role of hydration process in oocyte development.

Keywords: oocyte, kutum, Caspian Sea, hormone

P-033

Dominance and effects of conspecific urine on agonistic behaviour in the Norway lobster, *Nephrops norvegicus*

E. KATOH, T. BREITHAUPT

Department of Biology, University of Hull, Hull, HU6 7RX, United Kingdom.

Email: katohem@hotmail.com.

In the field of crustacean aquaculture research, chemical communication has so far received very little attention. This study aims to gain a better understanding of the role of urine borne chemical cues in relation to social interactions of the Norway lobster *Nephrops norvegicus*. The basis of dominance and the possibility of individual recognition was investigated; in particular the behavioural characteristics and the role of urine. In consecutive interactions the agonistic behaviour and fight duration were compared between *Nephrops* pairs that fought each other previously (familiar) and pairs derived from individuals with past fight history but no previous experience with one another (unfamiliar). The results indicate the existence of dominance recognition in *Nephrops*, as the dominant male remains so and losers remain losers in the two consecutive unfamiliar fights.

The role of urine born chemical cues in recognition were addressed by introducing either dominant male urine, female urine, freshly moulted female urine or injured male urine to a male fight. Urine cues appear to play an important role in social interaction as different behavioural outcomes were achieved by adding different chemical cues. We have demonstrated that *Nephrops* can be influenced by chemical cues. These chemical cues could be useful to control physiological process such as those underlying aggression and therefore could influence factors of importance to aquaculture. The knowledge enables to control the behaviour of *Nephrops* and could improve husbandry of decapod crustaceans in captivity.

Osmotic and ionic regulation of shrimp *Litopenaeus vannamei* and salinity carbonic alkalinity stress

LAI QIFANG, YAO ZONGLI, YING CHENGQI, WANG HUI, ZHOU KAI, TANG BAOJUN

East China Sea Fisheries Research Institute, Research Center for Saline Fisheries Technology; Chinese Academy of Fishery Sciences, Shanghai 200090, China

The main purpose of this study was to investigate the osmotic and ionic regulation of shrimp *Litopenaeus vannamei* and salinity and carbonic alkalinity stress. After exposing to different salinity levels of 5, 15, 25 and 35 ppt or in different carbonate alkalinity levels of 8, 20, 32 and 44mmol/L for 96 hrs the concentration of potassium, sodium, calcium and chloride in the haemolymph in shrimp were measured. The results indicated that: with increase of salinity and carbonate alkalinity of seawater, the concentration of osmotic and ionic concentrations in haemolymph of *L. vannamei* increased, their changing ranges were larger than the salinity and carbonate alkalinity changes. With salinity stress, the osmotic, sodium and chloride concentrations in haemolymph of shrimp *L. vannamei* were significantly affected ($p < 0.05$), the potassium and calcium concentrations were not significantly affected ($p > 0.05$). With correlation analysis, the isosmotic point of *L. vannamei* was determined to be 786.3mmol/L, the isoionic point of potassium, sodium, calcium and chloride was 324.3 mg/L, 7588.83 mg/L, 9775.11 mg/L, and 363.86 mg/L, respectively. *L. vannamei* showed hyperosmotic and hyperionic regulation below the isosmotic and isoionic points, and hypoosmotic and hypoionic regulation above them. With carbonate alkalinity stress, the osmotic, sodium and chloride concentrations in haemolymph of *L. vannamei* were significantly affected ($p < 0.05$), the potassium and calcium concentrations were not significantly affected ($p > 0.05$). Also potassium, sodium, calcium concentrations were lower than the control groups at the same salinity (5 ppt), high concentration of carbonate alkalinity may make these ionic in haemolymph loss.

Keywords: Litopenaeus vannamei, salinity, carbonic alkalinity, osmotic regulation, ionic regulation

An endocrine approach of osmoregulation in marine euryhaline teleosts

ABDOLALI MOVAHEDINIA, AHMAD SAVARI, MOHAMMADALI SALARI

Department of Marine Biology, Faculty of Marine Sciences, Khorramshahr University of Marine Science and Technology, Khorramshahr, P.O. Box: 669 Iran. Email: amovahedinia@yahoo.com.

The aim of this study was to determine the changes of cortisol and T3 (triiodothyronine) levels in a marine euryhaline teleost, in response to a wide range of salinities. The first experiment was carried out following exposure of juvenile yellowfin seabream, *Acanthopagrus latus* to 5, 20, 42 and 60‰ environments. In the second experiment, the fish were assigned to a gradual adaptation to freshwater. Yellowfin seabream was capable of tolerating direct exposure of salinities from 5‰ to 60‰ without showing mortalities. This species was also able to tolerate gradual decrease in salinity in the surrounding medium from seawater (42‰) to freshwater through a period of 10 days and successfully adapt to freshwater without mortality. This is the shortest period reported in a true marine fish for adaptation to freshwater through an acceptable experimental duration. The plasma cortisol level increased in groups exposed to 5 and 60‰. The highest cortisol level was observed in 60‰ treatment 12 hours after changing salinity. The cortisol level of the groups adapted to 60‰ and 5‰ conditions reverted to initial levels after 7 days and 24 hours, respectively. Following 24 hours of treatment, the T3 level resumed to the levels similar to the control, after a slight increase. There was no difference in cortisol and T3 levels among control and experimental groups during gradual adaptation to freshwater.

Keywords: osmoregulation, cortisol, triiodothyronine, yellowfin seabream, Acanthopagrus latus

Maximum swimming speed on juvenile Pacific bluefin tuna

F. DE LA S. SABATE, Y. NAKAGAWA, T. NASU, W. SAKAMOTO, S. MIYASHITA

Fisheries Laboratory, Kinki University, Wakayama, Japan.

Pacific bluefin tuna is a commercially important species that has become a target species for aquaculture in Japan. Rearing beyond post-flexion was first successful in 1979 and bluefin tuna was successfully cultured through its complete life cycle in 2002. Many studies have reported the early development of this species such as morphological development, morphogenesis of sense organs, and food selectivity on rotifers. However, high mortality from the juvenile stage caused cannibalism and wall collision is being reported. In this study,

I aim to improve survival of juvenile Pacific bluefin tuna through the adjustment of the flow field of the rearing tank.

Naturally spawned eggs were cultured from hatch until 37 days after hatching (DAH) in a 1kL transparent circular tank and a 3kL tank, at 25.5 to 28.6 °C. To measure the maximum swimming speed of Pacific bluefin tuna juveniles of seventy-two 24-29 DAH fish were used. Fish were gently introduced one at a time in a flume and water velocity was increased by 2cm/s in increments every 2 minutes until the juvenile could no longer swim against the current. The standard length (SL) of all the fish was measured. To study the effect of water current on the feed consumption thirty-two 37 DAH juveniles were transferred to each of two 500L and reared for 10 days. In one tank a circular current of 12cm/s was created by a pump, while in the other a pump was not used.

By 23 DAH all fish had metamorphosed (SL 15.0mm). SL of fish employed ranged from 11 to 26 mm and maximum swimming speed from 85.2 mm/s to 360 mm/s. In the rearing experiment, growth (both in SL and weight) and survival were similar in both types of tank. However, feed used on the current tank was 11 g while in the no current tank 24 g were used.

P-037

Effect of *Viscum album* and *Nigella sativa* extracts on non-specific immune response and efficacy of *Aeromonas hydrophila* vaccine in *Cyprinus carpio*

Alishahi. M.¹, Soltani. M.², Peyghan. R.¹

1. Department of Clinical Sciences, Faculty of Veterinary, Shahid Chamran University;

2. Department of Fish Disease, Faculty of Veterinary, Tehran University.

Usage of commercial antibiotics for disease treatment produce undesirable side effects and looking for suitable alternatives seems essential in aquaculture. *Viscum album* (Va) and *Nigella sativa* (Ns) were reported to have immunostimulating effects in mammals, but there is no report on immunostimulating effects of these extracts in fish. In this study the effects of Va and Ns extracts on non-specific immune response and efficacy of *Aeromonas hydrophila* (Ah) vaccine in common carp were investigated, using 300 juvenile *C. carpio* randomly divided into 6 groups. Three groups were immunised with *Aeromonas hydrophila* bacteria (A.h) (Immune groups) and two treatments of immune groups and non-immune groups were fed a diet containing 0.5% Va and Ns extracts. Blood samples were taken from 6 fish in each group every 10 days for 30 days. Samples were analysed for non-specific immunological parameters including: Lysozyme activity, bactericidal power, complement activity, total protein, globulin and albumin values. At the end of each treatment, fish in each group were challenged with Ah and mortality recorded for one week to evaluate Relative Percentage survival (RPS) in groups. Results showed that lysozyme activity and serum bactericidal activity were significantly increased in all Va treated groups ($P < 0.05$). But in

Ns fed groups, just non-immune treatment showed increase in lysozyme activity and no significant change observed in bactericidal activity ($P > 0.05$). Complement activity was not influenced by administration of Va and Ns extracts ($P < 0.05$). Total serum protein and globulin increased in Va treated groups compared to the controls ($P > 0.05$), but Ns didn't induce any change in serum proteins of fish ($P > 0.05$). RPS increased in Va fed fish, but did not show significant change in Ns fed fish. It can be concluded that Va is a proper candidate for stimulating the immune system and increasing the vaccine efficacy in common carp.

Keywords: Viscum album, Nigela sativa, Cyprinus carpio, Aeromonas hydrophila, non-specific immunity, lysozyme, complement

P-038

Effect of *Viscum album* and *Nigella sativa* extracts on some haematological factors and specific immune response on *Cyprinus carpio*

ALISHAHI. M.¹, SOLTANI. M.², PEYGHAN. R.¹

1. Section of Fish Disease, Department of Clinical Sciences, Faculty of Veterinary, Shahid Chamran University; 2. Department of Fish Disease, Faculty of Veterinary, Tehran University.

In this study the effect of oral administration of *Viscum album* (Va) and *Nigella sativa* (Ns) extracts on specific immune response and some haematological factors in *Cyprinus carpio* were investigated. Three hundred juvenile *C. carpio* were randomly divided into 6 groups, three were immunised with *Aeromonas hydrophila* bacterin (A.h) (immune groups) and two treatments of immune groups and non-immune groups were fed a diet containing 0.5% Va and Ns extracts. Blood samples were taken from 6 fish in each group every 10 days for 30 days. Samples were analysed for specific immunological (specific *A. hydrophila* antibody) and haematological (WBC, RBC, Hb, PCV, MCH and MCHC) parameters. Results showed that Ns extract did not induce any changes in anti Ah antibody in immune and non-immune groups compare to the controls ($P > 0.05$), But Va extract increased anti Ah antibody titer 20 and 30 days after administration ($P < 0.05$). Va extract did not induce any change in anti Ah antibody in the non-immune group. In the case of haematological parameters, significant differences were observed only in white blood cell count in the immune groups fed with Va 20 and 30 days after administration ($P < 0.05$). Oral administration of Va and Ns did not induce any change in RBC, Hb, PCV, MCH and MCHC values ($P > 0.05$).

It is concluded that although oral administration of Va enhances anti Ah antibody titer and WBC in the immune group, but Ns induced no significant change in immunological and haematological parameters in common carp. Besides the lack of haematological change after oral administration of these extracts can be inferred to be none toxic to the fish.

Keywords: Viscum album, Nigella sativa, Cyprinus carpio, Aeromonas hydrophila, haematological parameters, specific immunity

Haematological changes and clinical signs in red tilapia hybrid (*Oreochromis niloticus*) experimentally infected with *Streptococcus agalactiae*

MILUD ALSAID, HASSAN MOHD DAUD, ALI ABUSELIANA

Aquatic Animal Health Unit, Faculty Veterinary Medicine, Universiti Putra Malaysia, Serdang 43400, Selangor. Email: hassan@vet.upm.edu.my.

Haematological parameters are important for the evaluation of the health status of fish and can provide essential information for clinical diagnosis of fish diseases. An experiment was carried out to investigate the effect of *Streptococcus agalactiae* infection to the haematological parameters of red tilapia (*Oreochromis* spp.) when challenged intraperitoneally with 1.65×10^6 CFU/ml bacteria. The experiment comprised of three groups in triplicates i.e., non- inoculated fish (Gp.1), fish inoculated with 1 ml of sterile saline solution (0.65%) (Gp. 2) and fish inoculated with 1.65×10^6 CFU/mL of *S. agalactiae* diluted in 1 ml sterile saline (Gp. 3). Blood samples were collected at 0, 12 h and 1, 3, 5, 7, days post inoculation. The red blood cells (RBCs), haematocrit and haemoglobin concentration (Hb) values decreased dramatically below the normal levels compared to control groups (Gp. 1 & 2). In contrast, the white blood cell count (WBCs) increased significantly especially the lymphocytes together with mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC). Inoculated fish showed marked clinical signs including erratic swimming behaviour, "C-shaped" body curvature, exophthalmia, lethargy, fecal cast and haemorrhagic lesions during the experimental period. In conclusion, *S. agalactiae* could cause severe haematological changes in red tilapia (*Oreochromis* sp.).

Keywords: Haematology, clinical signs, Oreochromis sp, Streptococcus agalactiae

The significance of water quality profiling on prevalence of *Streptococcus agalactiae* infection in tilapia

MNA AMAL¹, AR ZULKAFI², S. MISRI³, M. ZAMRI-SAAD¹, A. SITI-ZAHRAH³, M.Y. SABRI¹, RAMLEY³, H. SHAHIDAN³

1. Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia; 2. Freshwater Fisheries Research Center, 71650 Jelebu, Negeri Sembilan, Malaysia; 3. National Fish Health Research Centre (NaFish), Fisheries Research Institute (FRI), 11960 Batu Maung, Penang, Malaysia. Email: amal_azmai@yahoo.com.

A study was conducted to investigate the significance of water quality profiling on prevalence of *Streptococcus agalactiae* in red tilapia in Malaysia. A total of 1,010 tilapia from floating net cage cultures were sampled for a period of 24 months. Swabs obtained from brain, eye and kidney were streaked directly onto blood agar. Pure isolates were subjected to Gram stain, catalase and oxidase tests, the API 20 STREP kit and PCR technique to confirm *S. agalactiae*. While sampling the tilapias, the water temperature and dissolved oxygen reading up to 20m deep were noted at 1 m interval. Water clarity and flow rate were also taken at several sampling points using Secchi disk and current meter. *S. agalactiae* were isolated, ranging between 2% and 40%, especially from April to October. During this period, the water temperature and dissolved oxygen readings were significantly ($p < 0.05$) higher than 29°C and 5 mg/l, respectively for up to 12 m deep. The water was significantly ($p < 0.05$) clearer during this period while the rate of water flow was slow at 8.90-3 cm/s. Clear water in deep lakes allowed deeper light penetration and increased the dissolved oxygen concentration by photosynthesis. However, the slow water flow and deep light penetration caused heat retention leading to high water temperature and increased susceptibility of tilapia to *S. agalactiae*.

P-041

Bacterial counts in two species (*Scomberomorus juttatus* and *Otolithes ruber*) of fresh south-harvested fish while loading in Kazeroon

MEHDI SHAH AHMAD GHASEMI¹, PARISA AZADNIA², MOHAMMAD HASAN RAHNAMA³, BIJAN DEHGHAN⁴, AMIR MAHMOOD RASTEGAR⁴

1. Fars Province Marine Hygienist; 2. Department of Food Hygiene and Public Health, School of Veterinary Medicine, Islamic Azad University, Kazerun Branch, Iran;
3. Veterinarian, Educated at the School of Veterinary Medicine, Islamic Azad University, Kazerun Branch, Kazerun, Iran; 4. Fars Province Veterinary Office Shiraz, Iran.
Email: parimehd2000@yahoo.com

This study focuses on the level of bacterial counts in two species of fish (*Scomberomorus juttatus*, *Otolithes ruber*) harvested from south coastal areas of Iran (Booshehr province) subjected to refrigerated-transportation to Kazeroon. In this study, 25 samples each of *S. juttatus* and *O. ruber* were studied for total bacteria, coliform and *Vibrio parahaemolyticus* counts. However, none of the samples exceeded the standard value (SV), and this study shows that the overall microbial quality of fresh south-harvested fish is acceptable and according to the standard values while it is loaded in Kazeroon. The bacteriological status of the samples is presented in Table 1 and the comparison of the bacteriological status of the samples (cfu/g) with the standard value is shown in Table 2.

Table 1. The bacteriological status of the fish samples (cfu/g)

| Species | Sampling area | Total bacterial count (SV*: 10 ⁶ -10 ⁷) | Coliform count (SV: 4.0×10 ²) | <i>V. parahaemoliticus</i> count (SV: 10 ²) |
|--------------------|---------------|---|--|--|
| | | Average | Average | Average |
| <i>S. juttatus</i> | Skin | 5.5×10 ⁶ | 6.0×10 ¹ | 0.9×10 ¹ |
| | Muscle | 10 ² | 1.0×10 ¹ | 0 |
| | Gills | 10 ⁵ | 1.5×10 ¹ | 1.2×10 ¹ |
| <i>O. ruber</i> | Skin | 10 ⁵ | 2.0×10 ¹ | 0 |
| | Muscle | 5.5×10 ² | 1.0×10 ¹ | 0 |
| | Gills | 10 ⁸ | 3.0×10 ¹ | 1.0×10 ¹ |

Table 2. Comparison of the bacteriological status of the fish samples (cfu/g) with the standard value

| Species | Sampling area | Samples exceeded SV of TBC* | | Samples exceeded SV of coliform | | Samples exceeded SV of <i>Vibrio</i> | |
|--------------------|---------------|-----------------------------|----|---------------------------------|---|--------------------------------------|---|
| | | Number | % | Number | % | Number | % |
| <i>S. juttatus</i> | Skin | 2 | 8 | 1 | 4 | 1 | 4 |
| | Muscle | 0 | 0 | 0 | 0 | 0 | 0 |
| | Gills | 4 | 16 | 1 | 4 | 0 | 0 |
| <i>O. ruber</i> | Skin | 3 | 12 | 0 | 0 | 1 | 4 |
| | Muscle | 0 | 0 | 0 | 0 | 0 | 0 |
| | Gills | 2 | 8 | 1 | 4 | 1 | 4 |

*TBC: Total Bacterial Count

P-042

Prevalence of protozoan and helminth parasites in Oranda gold fish (*Carassius auratus auratus* Linnaeus, 1758) in West Bengal

PROBIR K. BANDYOPADHYAY, AMLAN KUMAR MITRA AND SUKANTA MAJUMDER

Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani 741235, West Bengal, India. Email: prabir0432@hotmail.com.

An observational study was carried out to study the seasonal variation of infection in the oranda goldfish *Carassius auratus auratus*, a tiny aquarium fish by some protozoan and helminth parasites in the month of February and March, 2009. Thirty fishes were collected randomly and slides made from body smear, gills and tail regions. No myxozoans infection were found in these two months. *Trichodina* Ehrenberg, 1835 showed a similar pattern of prevalence (about 80 %) in both these months. The average prevalence of *Tripartiella* Lom, 1959 was 26.60 %. During these two months it was observed that in the month of February

Ichthyophthirius multifiliis Fouquet, 1876 infected 93.33% of fishes and *Gyrodactylus* von Nordmann, 1832 infected 46.66% of fishes. Whereas in the month of March, *Gyrodactylus* infected 86.66 % of fishes and *I. multifiliis* infected 40 % of fishes.

It can be concluded that in March when the temperature of the water is high, it accelerates the growth of the parasite *I. multifiliis*. While in February low temperature retarded development of the parasite which prolonged the life cycle stages.

P-043

Prevalence of WSSV infection in *Dendronereis* spp. from selected ponds in Indonesia

DESRINA^{1,2}, M.C. VERDEGEM¹, S.B. PRAYITNO², M. ZWART¹, J. VLAK¹, J. VERRETH¹

1. *Aquaculture and Fisheries, Wageningen University, Wageningen, the Netherlands;*
2. *Fisheries Department, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia*

White spot syndrome (WSS) which is caused by white spot syndrome virus (WSSV) is an important shrimp disease in Indonesia. It has been suggested that polychaetes might be one of many vectors of WSSV. The objective of this research was to determine the occurrence and prevalence of WSSV infection in *Dendronereis* spp., a common polychaete in Indonesia. Ponds that were sampled all had a history of WSSV infection, and varied in culture intensity.

We focused our survey on two locations: the Mahakam Delta in East Kalimantan (extensive ponds, minimum pond management) and Semarang in Central Java (semi-intensive and intensive shrimp ponds). A total of 11 ponds, including five ponds in the Mahakam Delta and six ponds in Semarang, were surveyed. In each pond, at 12 - 16 sampling points, sediment was collected and passed through a series of sieves to collect polychaetes. Per sampling point, *Dendronereis* spp. were separated and counted. Collected polychaetes were preserved in 70% ethanol for identification or 96 % ethanol for PCR purposes. The presence of WSSV was detected in the anterior part of *Dendronereis* in individuals from each of the sampled ponds (5- 16 individuals per pond) with one-step nested PCR. Further, we tried to locate the distribution of WSSV in *Dendronereis*. Worms were separated into an anterior part, body fluid (after removal of the anterior) and trunk (after removal of the anterior part and body fluid) and tested with 1-step PCR using a primer designed for ORF VP 26.

WSSV was present in polychaetes in all sampled ponds. Compiling data from all ponds, the prevalence of infection with WSSV in polychaetes was 63% (range 16 - 100% per pond). Extensive and traditional ponds tended to have a higher prevalence of infection (55 - 100%). Within the traditional extensive ponds, prevalence of WSSV in *Dendronereis* spp. was higher in the Mahakam Delta with 82 % than in Semarang with 40 %. WSSV was

detected only in the anterior part and body fluid, not in the trunk. The results indicated that *Dendronereis* might play a role in the epidemic of WSSV in shrimp ponds in Indonesia. Studies to determine tissue tropism and viral replication in *Dendronereis* are on-going.

Keywords: Dendronereis, WSSV, prevalence

P-044

Towards the development of alternative control strategies against *Saprolegnia diclina* on salmonid eggs

M.A.R. FARUK^{1,2,5}, A.H. VAN DEN BERG^{2,5}, KEITH DRYNAN³, I. DE BRUIJN², C.J. SECOMBES⁴, P. VAN WEST²

1. Department of Aquaculture, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh; 2. Aberdeen Oomycete Laboratory, University of Aberdeen, Aberdeen, Scotland, UK; 3. Landcatch Ltd; 4. Scottish Fish Immunology Research Centre, University of Aberdeen, Aberdeen, Scotland, UK; 5. contributed equally to the work.

Saprolegnia spp are one of the most important and devastating pathogens on salmonid eggs in fish hatcheries around the world. *Saprolegnia* is responsible for millions of pounds in losses to the aquaculture business. On average hatcheries seem to have losses of 10% per year. Up until the beginning of the century, the oomycete disease was kept under control with malachite green. This is an organic dye that is very efficient at killing the pathogen. However, the use of malachite green has been banned in the UK and around the world, due to its carcinogenic and toxicological effects.

As a result, new and effective strategies to control *Saprolegnia* infections on eggs are sought after. In this study, we investigate the infection process of *Saprolegnia* on eggs and made an inventory of all Saprolegniales species found on diseased eggs and in water samples of a Scottish hatchery. Furthermore we are in the process of characterising the molecular interaction in detail. Here we present our latest findings.

P-045

Evaluation of a high-throughput protocol for the purification of DNA/RNA from shrimp tissues for the detection of shrimp pathogens

CHOY LEN FONG¹, ROHAN SHAH², FIONA YL NG¹, KIM HALPIN¹, ELIZABETH SE LUO¹

1. Life Technologies, Singapore; 2. Life Technologies, Austin

An increasing number of new and emerging diseases are posing challenges for aquaculture, more specifically in the detection and management of these diseases. Diseases such

as white spot syndrome, yellow head disease and Taura syndrome have inflicted great economic and food production loss worldwide. Sample preparation including tissue homogenisation and DNA/RNA extraction is one of the critical steps in limiting rapid, reliable and sensitive pathogen detection in shrimp tissues. It represents the starting point for downstream processes such as pathogen detection, genotyping/sub-typing, microarray analysis and Northern blotting. Therefore, developing a sensitive, fast, reliable and high-throughput DNA/RNA extraction workflow is critical in controlling and managing aquatic disease in a timely manner.

In this study, we describe a MagMAX-based sample preparation workflow which integrates both tissue homogenisation and nucleic acid extraction to purify both DNA and RNA from shrimp tissues. The tissue types include gill, pleopod and whole shrimp. We have optimised and evaluated a protocol for the purification of DNA and RNA from these tissues using the magnetic bead based MagMAX-96™ Viral RNA Isolation Kit (Applied Biosystems). The extraction protocol takes approximately 30 min and can be automated with a MagMAX™ Express-96 Magnetic Particle Processors (Applied Biosystems). The purified DNA/RNA (8µl) extracted from shrimp tissues was then used in Path-IDTH qPCR (Applied Biosystems) for the detection of a shrimp endogenous and exogenous control. A synthetic exogenous control, Xeno DNA/RNA (Applied Biosystems) was spiked into tissue samples before extraction, and was subsequently assayed to assess extraction efficiency, PCR performance and any potential PCR inhibition.

The amplification of external spiked Xeno DNA or RNA shows that Xeno recovery is greater than 50% efficiency across all shrimp matrices, providing high sensitivity for pathogen detection by real-time RT-PCR/PCR. The integrity of purified DNA/RNA was confirmed with A260/A280 and β -actin, an endogenous gene. In addition, PCR inhibition was not observed. We then validated the optimised method and protocol against the white spot syndrome virus (WSSV)-infected field samples (n=20).

In conclusion, our optimised DNA and RNA purification protocol with the MagMAX-96 Viral RNA Isolation Kit provides a robust, simple and fast high-throughput workflow solution for purification of DNA/RNA from shrimp tissues for the detection of shrimp pathogens.

Isolation of *Lactobacillus sakei* BK 19 from Korean traditional food and screening of anti-bacterial activity against fish pathogens

YONG-JAE HAN, MIN-SUN KIM, MOON-SOO HEO

Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, College of Ocean Sciences, Jeju National University, Jeju 690-756, South Korea. Email: gksdydwo@naver.com.

Jeot-kal is a Korean traditional fermentation food usually produced by using fish and shellfish. Twenty strains of lactic acid bacteria were isolated from fish intestine, fermented fish foods and kimchis. Among these bacteria *Lactobacillus sakei* BK19 by was identified 16S rRNA PCR amplification and biochemical characteristics. These bacteria were screened for antagonistic activity against fish pathogenic bacteria and were able to inhibit the growth of pathogenic bacteria including *Vibrio parahaemolyticus*, *V. harveyi*, *V. mimicus*, *V. vulnificus*, *V. alginolyticus*, *V. salmonicida*, *Edwardsiella tarda*, *Streptococcus* sp., and *L. sakei* BK19 culture supernatants at pH 6.5 and temperature 25°C treated with catalase. A bacteriocin-like inhibitory substance of *L. sakei* BK19 was heat-stable (100°C for 10 minutes) and not-sensitive to lipase and α -amylase of However, this substance was inactivated by trypsin, pepsin, and protease. In this study the optimal culture condition of *L. sakei* BK19 was well grown under sucrose, maltose, and saccharose but lactose, mannitol was not utilised as a carbon source for their growth and fermentation. Also *L. sakei* BK19 was able to grow at 15 to 45°C culture temperature and 0 to 7% of NaCl concentration.

P-047

Effects of diet containing *Acanthopanax koreanum nakai* (Araliaceae) extracts on growth promotion and nonspecific immune response of *Paralichthys olivaceus* and *Oplegnathus fasciatus*

YONG-JAE HAN, RAMASAMY HARIKRISHNAN, MOON-SOO HEO

Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, College of Ocean Sciences, Jeju National University, Jeju 690-756, South Korea. Email: gksdydwo@naver.com.

We studied the effects of microorganisms extract mixed solution (AEMMS) on growth inhibition of fish pathogenic bacteria including *Vibrio harvei*, *V. campbellii*, *V. furnissii*, *V. alginolyticus*, *V. salmonicid*, *V. anguillarum*, *Edwardsiella tarda*, *Streptococcus iniae* and *S. parauberis* In addition, the effects of herb mixture on weight gain, feed efficiency, and survival rate of fish olive flounder (*Paralichthys olivaceus*) and parrotfish (*Oplegnathus fasciatus*) fed diets were investigated for 12 weeks. The extracts of *Acanthopanax*

koreanum Nakai originated from Jeju Island were provided from a stock farm product company. The micro-organisms used for fermentation of *Acanthopanax koreanum* Nakai extracts were *Lactobacillus acidophilus*, *L. brevis*, *L. plantrum*, and *Bacillus subtilis*. The fish were fed 2% of their body weight per day, two times daily until satiation, for a period of 12 weeks. The effects of the herb mixture on haematology, total protein (TP), glucose (GLU), glutamic oxaloacetic transaminase (GOT), and glutamic pyruvic transaminase (GPT) in serum were also measured. The production of oxidative radicals by neutrophils in blood during the respiratory burst was measured by NBT assays. There were no significant differences in weight gain and feed efficiency in olive flounder. Treated olive flounder GOT and GPT in serum decreased after 8 week, but there were no significant differences in GLU and TP among each group. In the present study herb mixture diet significantly increased the lysozyme activity compared to the control group. On the other hand, there was no significant NBT reduction. This study suggests that dietary herb mixture was effective against micro-organisms and enhances nonspecific immunity in olive flounder and parrot fish.

P-048

Effectiveness of chemotherapeutants and immunomodulation of scuticociliate *Philasterides dicentrarchi* in olive flounder

RAMASAMY HARIKRISHNAN, MOON-SOO HEO

Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, College of Ocean Sciences, Jeju National University, Jeju 690-756, South Korea. Email: rhari123@yahoo.com.

Philasterides dicentrarchi is a scuticociliate parasite that causes fatal scuticociliatosis in farmed olive flounder *Paralichthys olivaceus* in Jeju Island, South Korea. The average monthly prevalence of scuticociliatosis with *P. dicentrarchi* infections was 40 ± 3 to $79\pm 2\%$ in the month of May to July from 2000 to 2004. The prevalence of mixed infection along with *Vibrio* spp. infection was $49\pm 8\%$ than that of scuticociliatosis alone. To date no effective control measure has been described and large economic losses continue. The present study on three chemotherapeutants, formalin, hydrogen peroxide and Jenoclean were used for bath treatment. Jenoclean and hydrogen peroxide at a low concentration of 50 ppm proved effective in vitro, but formalin was only moderately effective. Either hydrogen peroxide or Jenoclean are the promising compounds effective at low concentrations with short application time for *P. dicentrarchi*. These substances were evaluated on day 10, 20, and 30 for their ability to enhance innate immune response and disease resistance in olive flounder against *P. dicentrarchi* after chemotherapeutants bath treatment with 100 ppm for 30 min per day. All the tested immune parameters were enhanced by treatment with Jenoclean, but not formalin and hydrogen peroxide. The results suggest that Jenoclean bath treatment can be used for ensuring the health of cultured marine fish against the internal parasite *P. dicentrarchi*.

Probiotics, triherbal and azadirachtin enriched diets on haematological and biochemical changes in *Cirrhinus cirrhosus* against *Aphanomyces invadans*

RAMASAMY HARIKRISHNAN, MOON-SOO HEO

Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, College of Ocean Sciences, Jeju National University, Jeju 690-756, South Korea. Email: rhari123@yahoo.com.

Cirrhinus cirrhosus (63±2 g) were intramuscularly (i.m.) injected with 2.3x10⁷ CFU ml⁻¹ of *Aphanomyces invadans* (isolate B99C). The haematological and biochemical parameters were studied in the experimental and control groups on the 30th day. In the infected untreated group (I) the white blood cell count (WBC) significantly increased (P<0.05) from the control, while no change was observed in groups fed with probiotics, herbal and azadirachtin supplementation diets. The hemoglobin (Hb) and hematocrit (Hct) levels significantly decreased in group I. Interestingly, infected fish fed with probiotics, herbal, and azadirachtin supplementation diets groups did not differ (P>0.05) from the control. The percentage of lymphocytes (LYM), monocytes (MON), eosinophils (EOS) and neutrophils (NEU) significantly decreased. The total protein (TP), glucose (GLU), calcium (CAL) and cholesterol (CHO) levels were affected (P<0.05) in group I whereas these values after probiotics, herbal, and azadirachtin supplementation diet treated groups were restored near control group. The present study suggests that the infected fish after administration with probiotics, herbal and azadirachtin supplementation diets for 30 days protect the haematological and biochemical parameters in *C. cirrhosus* against *A. invadans*.

The study of acute toxicity of lead nitrate Pb(NO₃)₂ metal salt and behavioural changes of milkfish (*Chanos chanos*)

ASKARI HESNI, M.¹, SAVARI, A.¹, DADOLAH, A.¹, MORTAZAVI, M.S.², REZAAE, M.³

1. Department of Marine Biology, Faculty of Marine Science, Marine Science and Technology University, Khoramshahr; Iran. 2 Persian Gulf and Oman Sea Marine Biology and Ecology Research Center, Bandarabbas, Iran; 3 Department of Marine Biology, Faculty of Science, Hormozgan University, Bandarabbas, Iran. Email: mahesni@gmail.com.

The environment is continuously polluted by both natural factors and human activities, such as industrialisation and mining processes. Heavy metals are a major problem because they are toxic and tend to accumulate in living organisms. In this study was on the 96-h LC₅₀ values of lead nitrate (Pb(NO₃)₂) and its effects on behavioural changes of milkfish (*Chanos chanos*). Young juvenile milkfish (64±1.2 g, SL: 16.7±0.4 cm) were exposed to

Pb at concentrations of 110, 180, 250, 320, 390, 460 and 530 mg/l. The experiments were performed in triplicate, and behavioural changes were determined for each concentration. Water quality parameters of the test seawater were: hardness, 193.4 mg/l as CaCO₃; pH, 7.6 to 8.1; dissolved oxygen concentration, 6.7 to 7.8 mg/l; and salinity, 38.3 psu. The data obtained were statistically evaluated by the use of EPA computer program based on Finney's Probit Analysis Method. The 96-h LC50 value was found to be 426.5 mg/l in a static bioassay test system. The behavioural changes observed in fish were, hyperactivity, loss of balance, vertical and downward swimming patterns, convulsions, attaching to the surface, increased mucus secretion, and some of them in high concentration were schooling, motionless, difficulty in breathing gathering around the ventilation filter and body colourless and all fins were bloody. There were no behavioural changes and deaths observed in the control group throughout the experiment. The result showed that acute lead toxicity severely affects the mortality and normal behaviour which may be deleterious for milk fish.

Keywords: heavy metal, LC₅₀, lead, behaviour, Chanos chanos

P-051

Antibacterial activity of bacterial metabolites produced by *Bacillus vallismortis* BK6 isolated from Jeot-kal

IK-SOO JANG, KYUNG-MI MOON, BONG-KUN JHON, MOON-SOO HEO

Marine Applied Microbes & Aquatic Organism Disease Control Lab, Department of Aquatic Life Medicine, College of Ocean Science, Jeju National University, Jeju 690-756, South Korea. Email: ishilhil@naver.com.

Jeot-kal is a salted fermented food in Korean cuisine. It is made with a number of seafood, such as shrimp, oysters, shellfish, fish, fish eggs, and fish intestines. These products are usually fermented using certain types of sand microorganism enzymes. It is not only as a source of protein, but due to its peculiar flavour, relative abundance of free amino acid, and taste related components, but also a subsidiary material of kimchi or spices. Six bacterial strains were isolated from several Jeot-kal using MRS agar medium. The antibacterial activity was found to be stable after heat and various enzyme treatments at pH ranges from 3.5 to 10.5. The antibacterial compound was inactivated by pepsin treatment and suggesting competitive inhibition of proteinaceous nature. This study investigated the effect of the antibacterial and antioxidant activity of solvents (ethyl acetate, butanol) supernatant from *B. vallismortis* strain BK6. The minimum inhibitory concentration of solvent extract was 1mg/ml against *S. parauberis*.

**Characterisation of antimicrobial proteins produced by *Phaeobacteri*
inhibens KJ-2**

IK-SOO JANG, YUN-BEOM KIM, MOON-SOO HEO

Marine Applied Microbes & Aquatic Organism Disease Control Lab, Department of Aquatic Life Medicine, College of Ocean Science, Jeju National University, Jeju 690-756, South Korea. Email: ishlhil@naver.com.

Antimicrobial producing bacterium, *Phaeobacter inhibens* KJ-2 was isolated and identified by biochemical characterisation and 16S rRNA sequence analysis from marine organism Sea hare eggs. Phenotypic classification of *P. inhibens* KJ-2 was identified as aerobic, Gram-negative, motile bacteria with brown-pigmented colonies. Production of antimicrobial compound and higher growth of *P. inhibens* KJ-2 were observed at 20°C for 24 hours. Optimum conditions for production antimicrobial compound of *P. inhibens* KJ-2 were determined as media containing 1.5% sorbitol, 0.8% NH₄NO₃, 4% NaCl at pH 6.0 and temperature at 20°C. However, production of antimicrobial compound was inhibited by mineral sources. Antimicrobial compound of *P. inhibens* KJ-2 was stable within a pH range from 3 to 10 and temperature ranging from 40-121°C. Therefore, our results confirmed that antibiotic compound isolated from *P. inhibens* KJ-2 provided a potential biological agent for controlling fish pathogenic bacteria.

Disease and stress resistant common carp: combining quantitative, genomic, proteomic and immunological markers to identify high performance strains, families and individuals

Z. JENEY, P. DIXON, I. OLESEN, A. BOGERUK, A. COSSINS, N. MUGUE, B. McANDREW, G. JENEY

Research Institute for Fisheries, Aquaculture and Irrigation (HAKI), Anna liget 8., H-5540 Szarvas Hungary.

Several serious disease problems (e.g. koi herpesvirus (KHV) spring viremia of carp (SVC), and erythrodermatitis as well as septicemia caused by *Aeromonas hydrophila*) threaten the sustainability of carp farming in many countries and have the potential to greatly reduce yields in all carp producing countries inside and outside of Europe. Using the HAKI carp genebank a series of crosses between two selected (TATA and Szarvas15) and two wild strains (Duna and Amur) produced 96 test families which were split into a number of replicates as a resource for the project. Controlled challenges for *Aeromonas* and KHV on two separate replicate groups identified families with high and low resistance for both diseases. Heritabilities were estimated and found low for *A. hydrophila* resistance and very

high for KHV resistance. Based on the results of the disease challenges families were ranked in respect to their disease resistance. Tissue and serum samples were collected from the 10 highest and 10 lowest responding families for each disease as a resource for functional genomic analysis, proteomic and immunological assay. Differences in gene expression within high and low, viral (KHV) and bacterial (*A. hydrophila*), responding families under challenge and normal condition were assessed using a well characterised carp microarray. The same fish were also used to look for differences in serum/plasma protein expression using a proteomics approach. In addition, a variety of immunological parameters were investigated to identify potential practical markers for disease resistance. A medium resolution linkage map was developed using a range of existing and new Type I & II markers. The quantitative genetic and molecular data was modelled to inform on the optimum design of future breeding programmes in Europe and other carp farming countries. A catalogue of the carp strains was published. Stocks of 10 highest and 10 lowest responding families to both diseases are being maintained at the coordinator institute (HAKI) and available for further studies.

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P-054

Prevention from saprolegniosis by means of silver nanoparticles (AgNPs) and silver zeolite (SZ)

SAYED ALI JOHARI, MOHAMMAD REZA KALBASSI

Department of Fisheries sciences, Faculty of Marine Sciences, Tarbiat Modares University, Tehran, I. R. Iran. Email: sajarah@gmail.com.

Fungal diseases are among the most detrimental factors in egg incubation next to bacterial diseases. Saprolegniosis is the most common fungal disease in freshwater hatcheries. Fish eggs are very susceptible to fungal diseases during the late stages of their development.

Recently, various inorganic antibacterial and antifungal materials containing silver have been developed and some of them are in commercial use. Silver nanoparticles (Ag NPs) and silver zeolite (SZ) are two of them. However, we don't have any information regarding the antibacterial and antifungal effects of silver compounds on fish disease. To fill this gap, effects of silver zeolite and colloidal silver nanoparticles on in-vitro growth of fish pathogenous species of *Saprolegnia* sp. was investigated.

The antifungal activity of silver nanoparticle and silver zeolite was evaluated by determining the minimum inhibitory concentrations (MICs) by using two-fold serial dilutions of colloidal nanosilver and silver zeolite in GY-agar at 22°C. The growth of *Saprolegnia* sp. was compared to the growth on nanosilver-free and silver zeolite-free agar controls. Results

show that silver nanoparticles and silver zeolite had inhibiting effect on in-vitro growth of the tested fungi. The MIC of silver nanoparticles and silver zeolite for *Saprolegnia* sp. were 1,800 and 600 ppm respectively; which are approximately equal to 2% silver nanoparticles colloid and 2.5% silver zeolite powder. Although the MIC value of these silver products is high as compared to other antifungal materials which are used for direct treatment of eggs or larva, but since those products could be easily mixed to or coated on other substances for indirect treatment, it seems to be useful disinfectant agents against *Saprolegnia* sp. Results suggested that silver nanoparticles and silver zeolite may be good candidates for indirect use in the aquaculture industry. Based on the MIC results, it could be suggested that mixing of approximately 2% silver nanoparticles or 2.5% silver zeolite powder to structure of aquaculture equipments may completely inhibit *Saprolegnia* sp. growth. Now it is necessary to find out the applicable methods to use these materials in aquaculture systems such as fish ponds, hatcheries, and aquariums in vivo. For example silver nanoparticles could be coated on water filter media (Such as activated carbon, zeolite, foams, etc) which are used in recirculation systems and hatcheries to reduction bacterial and fungal diseases which transmitted and spread through water. Also silver nanoparticles and silver zeolite can be mixed to polymeric structures of aquaculture materiel such as fiberglass or polyethylene troughs, trays, culture tanks, and other parts of propagation and rearing instruments as an antifouling agent. Therefore, in terms of potential use, the incorporation of nanoparticulate silver and silver zeolite into surfaces and other objects in aquaculture industry could be envisaged.

Keywords: antifungal; Saprolegnia sp.; silver nanoparticles; silver zeolite; water mould; indirect treatment

P-055

The adaptability evaluation of environmental water to functional materials feeding in abalone (*Haliotis discus discus*)

Chang-Su Kim¹, Han-Sol Lim¹, Min-Seok Jwa¹, Mi-Kyung Choe², In-Kyu Yeo¹

1. College of Ocean Sciences, Cheju National University, Jeju, Korea; 2. Aquaculture Research Institute, NFRDI, Korea. Email: fekiller@naver.com.

The primary purpose of these studies was to develop functional materials (fermented *Ecklonia cava*, *Citrus pomace* powder) as additives for abalone farming. In conducting this experiment, abalone was used to test the saline stress affects based on parameters such as haemolymph, antioxidant enzyme activity (CAT and SOD), phenoloxidase activity, lysozyme activity in gill and blood. In the first experiment, abalone (average shell length 4.1 ± 0.16 cm shell width 2.7 ± 0.13 cm weight 7.9 ± 0.11 g) fed seaweed, and maintained at about 33.04 \pm 0.41 psu ~ 33.52 \pm 0.56 psu in indoor water tank. Abalones were cultured at 0, 3, 6, 12, 24 and 48 hours for 25, 30, 33, and 35 psu, respectively. In the second experiment, abalone were fed functional materials, and were cultured at 0, 3, 6, 12, 24 and 48 hours for 25 psu

respectively. In the first experiment, survival rates of abalone were 100% at 33, 35 psu, but 25 psu and 30 psu of salinity it was 93% and 97%. Haemolymph changes of abalone affected by the model with 25 psu of salinity showed decreasing rate of haemolymph. On the other hand, the model with 30psu of salinity had increasing numbers of haemolymph. After 6 hours, there was a decline in animals at 25psu. In addition, after 24 hours, at 30 psu salinity rate of haemolymph decreased. SOD activity increased at 3 hours from 25 psu and increased 48 hours from 25 psu, 30 psu. CAT activity increased at 48 hours from 25 psu. Phenoloxidase activity of abalone decreased at 48 hours from 25 psu, 30 psu. Lysozyme activity of abalone increased at 12 hours and decreased at 48 hours from 25 psu. In the second experiment, survival rates of abalone were 100% at 12 hours. The test models in 24 hours and 48 hours of salinity had some dead abalone. Haemolymph counts of abalone showed an increase at 3 hours and decreased from that of the control group. Haemolymph increased at 48 hours from CP+ECR 4%, 6% group. SOD activity was not significantly different between the experimental groups. CAT activity was not significantly difference between the ECR (fermented *Ecklonia cava*) and the control group. Phenoloxidase activity of abalone was not significantly different between the ECR 6% and control group, but the other experimental groups showed a lowering. Lysozyme activity of abalone was not significantly different between the ECR 6%, CP (*Citrus pomace powder*) + ECR 2% and control group, but other groups showed a decrease.

P-056

Antagonistic activity of compounds produced by proteobacteria *Oceanospirillales zooshikella* spp. JE-34 against fish pathogens

JU-SANG KIM, DONG-HWI KIM, MOON-SOO HEO

Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, College of Ocean Sciences, Jeju National University, Jeju 690-756, South Korea. Email: jusangj@naver.com.

Microbial byproducts are one of the richest sources of chemicals and pharmaceutical substances. Secondary metabolites, such as prodigiosin pigments act as antibiotics, immunomodulators, antidiabetics, and anti-cancer agents. In the present study, the antimicrobial activity of culture broth and bacterial cell extracts of *Zooshikella* sp. JE-34 were tested against fish bacterial and fungal pathogens. The strongest inhibition zones were exhibited such as *Vibrio parahaemolyticus* (42, 50 and 54 mm), *V. salmonicida* (50, 43 and 46 mm), *V. vulnificus* (54, 51 and 52 mm), Gram-positive bacteria *Streptococcus parauberis* (58, 62 and 63 mm), and fungi *Candida albicans* (45, 51 and 44 mm). Strongest minimum inhibitory concentration were found against all tested pathogens, except *V. harveyi* and *V. furnissii* ($P > 0.05$) at concentration of 500 mg/ml or g/ml. Methanol and dimethyl ether bacterial cell fraction extracts showed highest activity antimicrobial against *S. iniae* and *S. parauberis*. We focused on a potential strategy to treat human and fish infections. Further need in vivo efficacy of prodigiosin in experimental animal models, such as marine

olive flounder. This study suggested that the *Zooshikella* sp. containing prodigiosin as an alternative for current antibacterial and antifungal agents.

P-057

Administration of *Zooshikella* spp. JE-34 containing diet on innate immune response and disease resistance of *Paralichthys olivaceus* against *Streptococcus iniae*

JU-SANG KIM, RAMASAMY HARIKRISHNAN, MOON-SOO HEO

Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, College of Ocean Sciences, Jeju National University, Jeju 690-756, South Korea. Email: jusangi@naver.com.

Streptococcus iniae is one of the important fish pathogens, an etiological cause of streptococcosis causing significant economic loss in wild and farmed fish worldwide. *Zooshikella* sp. strain JE-34 was isolated from marine sediment in the East China Sea that produce anti-microbial red-pigment prodigiosin. These have antibiotics, immunomodulator, anti-diabetic, and anti-cancer activity. The present study on *Zooshikella* sp. JE-34 was chosen as a promising candidate of probiotic administered through feed at three different concentration i.e. Low (3.4×10^4 , n = 50), medium (3.5×10^6 , n = 50), and high (3.4×10^8 , n = 50) cfu ml⁻¹ in olive flounder against *S. iniae* to assess the innate immune response and disease resistance. The fish were monitored on weeks 1, 2, 4, 8, 12 and 16. All diets had the innate immune parameters, such as superoxide anion production, phagocytic and lysozyme activity were after 8th week. The weight gain significantly increased after 4th week. The mortality of olive flounder was 25% in high concentration diet group and low and medium concentration enriched diets the mortality was 40% and 35% respectively. Infected untreated group was 85% while there was no mortality in the control group. The results suggested that *Zooshikella* sp. strain JE-34 enriched diets could enhance the innate immune response and disease resistance in *P. olivaceus* against *S. iniae*.

P-058

BRICHOS domain containing leukocyte cell-derived chemotaxin 1-like cDNA from disk abalone *Haliotis discus discus*

YUCHEOL KIM, MAHANAMA DE ZOYSA, SUKKYOUNG LEE, HYOWON KIM, JEHEE LEE

Department of Marine Life Sciences, School of Marine Biomedical Sciences, Jeju National University, Jeju Special Self-Governing Province, 690-756, Republic of Korea

BRICHOS domain containing leukocyte cell-derived chemotaxin 1-like cDNA was cloned from disk abalone (*Haliotis discus discus*) and named as AbLECT-1. A full-length (705 bp) of

AbLECT-1 cDNA was composed of 576 bp open reading frame that translate into a putative peptide of 192 amino acids. Its deduced amino acid sequence had 15.5 and 27.8% identity and was similar to human LECT-1, respectively. Quantitative real-time PCR analysis showed that the AbLECT-1 mRNA was constitutively expressed in abalone haemocytes, gills, mantle, muscle, digestive tract and digestive gland in a tissue-specific manner. Moreover, AbLECT-1 transcription level was significantly ($p < 0.05$) up-regulated after challenge with *Vibrio alginolyticus*, *Vibrio parahaemolyticus*, and *Listeria monocytogenes* suggesting that it may involve in immune response reactions against bacterial challenge in abalone.

Keywords: abalone leukocyte cell-derived chemotaxin 1, invertebrate, mollusc, haemocytes

P-059

The effect of rearing density on digestibility, growth, and immune responses in juvenile amur sturgeon, *Acipenser schrenckii*

DA PENG LI^{1,2}, CONGXIN XIE^{1,2}, XIAOTAO SHI³

1. College of Fisheries, Huazhong Agricultural University, Wuhan, China; 2. Key Laboratory of Freshwater Biodiversity Conservation and Utilization of Ministry of Agriculture, the People's Republic of China; 3. College of Chemistry and Life Science, China Three Gorges University, Yichang, China. Email: ldp@mail.hzau.edu.cn.

Rearing density is considered as a major factor influencing growth, health, and welfare of fishes in aquaculture. A 60-day experiment was conducted to evaluate the effect of rearing density on growth, feeding rate, digestibility, lysozyme activity, and plasma concentration of C3 and C4 in juveniles Amur sturgeon. The mean initial weight of sturgeon was 43.90 ± 1.75 g, and initial rearing densities were 0.53 (LSD), 1.17 (MSD), and 2.14 (HSD) $\text{kg} \cdot \text{m}^{-2}$ respectively. The results showed that growth efficiency, specific growth rate and individual daily weight gain significantly increased with the decrease of rearing density, while, net yield of group increased with the increase of the rearing density. However, there was no significant difference in feeding rate between three groups. Digestibility of fish in HSD group was significantly lower than that in LSD group, as well as MSD group. These results suggest that rearing density may inhibit fish growth by reducing the digestibility of fish. Lysozyme activity and concentration of plasma C3 and C4 of fish in HSD group were significantly lower than those in LSD group during the initial experimental period (0 -15 d). But, there were no significant differences between these densities on these parameters at the end of the experiment. No significant difference of spleen weight index among three groups was found. We draw the conclusion that high rearing density has a temporary negative effect on non-specific immune function of sturgeon.

Keywords: rearing density, lysozyme activity, digestibility, growth, sturgeon

Chemotherapeutants induced alteration in shell formation of freshwater bivalve, *Lamellidens corrianus* (LEA)

H.P. NANDURKAR¹, S.P. ZAMBARE²

1. Department of Zoology, Sant Gadge Baba Amravati University, Amravati. (M.S.) 444 602;
2. Department of Zoology, Dr.B.A.Marathwada University, Aurangabad (M.S.) 431 004. Email: hema_nagpure19@rediffmail.com.

The attraction and fancy for pearls has been eternal since times immemorial. An injury or a coincidental introduction of a foreign body, between the shell and mantle responded in the formation of a pearl. The shell of most molluscs and practically all bivalves, like pearl oyster and also the freshwater mussels, is composed of three layers. The shell and pearl reflect the similarity in terms of its structure and formation. In artificial pearl culture, to improve the pearl yield and quality an implantation is made and this little surgery is followed by the post-operational care. In the post-operational care exposure to antibiotics reduces the mortality rate of the bivalves.

In the present study tetracycline, chloramphenicol and trimethoprim were tested to detect the proper drug for this purpose. After bivalves exposure to LC50/10 concentration of tetracycline, chloramphenicol and trimethoprim for five months, the bivalve of each group was drilled with a dentist drill of 1 mm bore at three different sites, first at umbo, second at middle level and third at the edge of the shell to find out the rate of shell formation. The bivalves were kept in different doses of antibiotics. The chloramphenicol treatment gave better results than other two selected antibiotics tetracycline and trimethoprim. Overall results of bivalves indicate rapid rate of shell formation in moderate sized (60-70 mm) animals. The highest rate of shell formation was near edge (210.630 $\mu\text{m}/\text{month}$) in comparison with tetracycline (134.120 $\mu\text{m}/\text{month}$) and trimethoprim (123.253 $\mu\text{m}/\text{month}$) respectively was observed in moderate sized *L. corrianus*. With regard to the question of survival after surgery chloramphenicol seems to be promising.

Multiplex PCR detection of *Streptococcus agalactiae* isolated from *Oreochromis niloticus*

NUR-NAZIFAH, M,M.Y. SABRI, M. ZAMRI-SAAD, SITI-ZAHRAH, A., AMAL, A.M.N.

Faculty of Veterinary Medicine, University Putra Malaysia, 43400, Serdang, Selangor, Malaysia.
Email: ambuliana@yahoo.co.uk.

Streptococcus septicemia is a disease that is caused by *Streptococcus* sp. Streptococcal disease in fish was first reported in 1957, in cultured rainbow trout in Japan (Hoshina et al., 1958). Streptococcal (Strep) diseases of fish are not common; however, when they do occur, significant mortality can result (Roy et al., 2002). In *Oreochromis niloticus*, pathogenic *Streptococci* that had been reported to cause disease included *S. agalactiae* (Eldar et al., 1994) and *S. iniae* (Klesius et al., 1999). *S. agalactiae* shown to be more aggressive than any other environmental bacteria, where mortality may reach 100% (Ferguson et al., 1994). In Malaysia, most *Streptococcus* sp. isolated is *S. agalactiae* and it affects various sizes of fish. But, mainly outbreaks involves fishes 150g weight and above. *S. agalactiae* (group B streptococcus, GBS) is a major aetiological agent of septicemia and meningoencephalitis in fish (Evans, Klesius & Shoemaker 2006). From Gram staining procedure, *S. agalactiae* is cocci and chain in shape. Some biochemical test can be done to identify this bacterium. However, the development of multiplex polymerase chain reaction (PCR) was a good tool in identifying *Streptococcus agalactiae* as it can be identified molecularly. First, 50 CPS isolates, which were examined using API 20 Strep in the present study, were previously isolated from clinically diseased fish at different location of dam and lakes (Siti Zahrah, 2002). Isolation was performed during sampling and brought to the lab for further determination. Total cellular DNA was extracted with Wizard Genomic DNA Purification Kit (Promega, USA) according to manufacturer's protocol. All PCR assays were performed in a Mastercycler personal (eppendorf). Primers that were used will identify the gram positive gene for gram positive bacterial (P2F-NR) (Nora, 2000) and 16S-23S rRNA intergenic spacer region which was the conserve region of *S. agalactiae* bacterium. The 25- μ L PCR mixtures consisted of 1 μ L of DNA preparation, 17.5 μ L of water, 2.5 μ L of PCR buffer, 2.0 μ L of MgCl₂, 0.5 μ L of dNTPs, 1 μ L of each primer (100 μ M) and 0.5 μ L (5U/ μ L) of *Taq* DNA polymerase.

Effect of red pigment produced by marine actinomycetes *Streptomyces albobriseolus* strain CY-1 on immune response in olive flounder, *Paralichthys olivaceus*

CHANG-YOUNG SONG, MAN-CHUL KIM, LI-NA KIM, JU-SANG KIM, MOON-SOO HEO

Marine Applied Microbes & Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Science, College of Ocean Science, Jeju National University, Jeju 690-756, South Korea. Email: 102bn@naver.com.

Streptomyces albobriseolus strain CY-1 of marine actinomycetes was isolated from marine sources in Jeju Island. The effects of red pigment producing marine actinomycetes *Streptomyces albobriseolus* CY-1 culture extract supplemented diet on haematology and disease resistance in olive flounder, *Paralichthys olivaceus* were tested. The growth rate after 4 weeks of *P. olivaceus* was found to be 150.2g fish feeding without addition of actinomycetes extract. And it was found to be 180.5g fish fed with SBME-18 of 1%. As the result of GOT and GTP enzyme of treated supplemented diet group in blood, was low than the control group. The oxygen free radical in phagocyte of fish was found to be higher in all experimental groups fed with lactic acid bacteria of 2%. Low cumulative mortality of *P. olivaceus* was observed in the group fed with actinomycetes extract supplemented diet against *S. iniae* for 10 weeks.

Isolation and identification of antibiotic producing *Phaeobacteria inhibens* strain KJ-2

CHANG-YOUNG SONG, YUN-BEOM KIM, JU-SANG KIM, MOON-SOO HEO

Marine Applied Microbes & Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Science, College of Ocean Science, Jeju National University, Jeju 690-756, South Korea. Email: 102bn@naver.com.

Phaeobacteria inhibens strain KJ-2 was isolated from marine Sea hare eggs. The isolated strain was Gram-negative, aerobic bacterium with brown-pigmented colonies. The highest growth of *Phaeobacteria inhibens* KJ-2 was observed at 20°C for 24 hours. Production of antimicrobial compound was determined with acylated homoserine lactones (AHLs) production and regulated by Quorum sensing. The identified *Phaeobacteria inhibens* KJ-2 bacterium showed potent antibacterial activity against fish pathogenic bacteria including *Vibrio logei*, *V. campbellii*, *V. mimicus*, *V. vulnificus* and *V. salmonicida*. *V. anguillarum* cell wall was damaged after 3 hr incubation with *Phaeobacteria inhibens* KJ-2 antibiotic compound using the scanning electron microscope. Therefore, our results suggested that

antibiotic compound of *P. inhibens* KJ-2 has a potential biological agent for controlling fish pathogenic bacteria.

P-064

Molecular characterisation and expression analysis of inhibitor of NF- κ B (I κ B) cDNA from Manila clam (*Venerupis philippinarum*)

YOUNGDEUK LEE, YUCHEOL KIM, HYOWON KIM, JEHEE LEE

Department of Marine Life Sciences, College of Ocean Sciences, Jeju National University, Jeju Special Self-Governing Province 690-756, Republic of Korea. Email: lyd1981@gmail.com.

Inhibitors of NF- κ B play a significant role in NF- κ B pathway by regulating various biological processes such as immune response, inflammation, apoptosis, cell growth, differentiation and proliferation. Manila clam is an economically important bivalve species in Korean aquaculture. However, occurrence of disease outbreaks has increased significantly due to many pathogenic infections including parasites, bacteria, and viruses. Therefore, molecular understanding of immune response inhibitors of NF- κ B could give better understanding of immune system of manila clam which helps to prevent and control diseases.

In the present study, we report the identification, molecular characterisation and transcriptional analysis of I κ B from Manila clam (*Venerupis philippinarum*) which was named as Vp-I κ B. The Vp-I κ B cDNA contains 1029 bp open reading frame (ORF) that encodes 343 amino acids peptide. The predicted VpI κ B has 38 kDa molecular mass and estimated 4.6. isoelectric point (PI). Also, it has characteristic five Ankyrin repeats domains similar to known I κ B counterparts. Our results revealed that identified VpI κ B has the highest identity (32%) to Pacific oyster I κ B.

Quantitative real time PCR results showed that VpI κ B expressed ubiquitously in all selected Manila clam tissues including hemocytes, gills, mantle, muscle and digestive tract. Based on our results, we can assume the presence of other NF- κ B pathway molecules in Manila clam

*Keywords: Bivalve; inhibitor of NF- κ B (I κ B); Manila clam (*Venerupis philippinarum*); real-time PCR*

Epidemiology of white spot syndrome virus (WSSV) in pond culture of shrimp, *Penaeus monodon*, in the Philippines

ELEONOR A. TENDENCIA^{1,2}, ROEL H. BOSMA², JURGENNE H. PRIMAVERA¹, JOHAN A.J. VERRETH²

1. Aquaculture Department Southeast Asian Fisheries Development Center Tigbauan 5021 Iloilo, Philippines; 2. Aquaculture and Fisheries Group, Wageningen University, The Netherlands.

Disease due to whitespot syndrome virus (WSSV) is one of the most important among the shrimp diseases. Not all WSSV infections result in outbreaks. Factors related to pond location and management practices seem to affect WSSV epidemiology. The occurrence of stress has been suggested as one of the WSSV risk factors. Stressors are usually related to the physicochemical properties of both water and pond bottom. This report will summarise scientific evidence of WSSV risk and protective factors at pond level.

Cross sectional studies were done to identify physicochemical water parameters, ecological factors and aspects of management protocols that affect WSSV epidemiology. Results showed that stocking during the rainy season, fluctuation of temperature and pH are important WSSV risk factors that will result in an infection but not necessarily in an outbreak. Further exposure to stressors such as high salinity and high temperature are important factors for an infection to result in an outbreak. The risk of an infection is reduced when the water temperature is high, and salinity fluctuations are small. An ecological factor identified as an important WSSV risk factor for both polyculture and monoculture farms, was sharing of water source with other farms. Among the farm management protocols, deposition of sludge on dikes, high stocking density and feeding with live molluscs, were important WSSV risk factors in polycultured ponds. Biosecurity measures and the use of probiotics had no significant effect on WSSV incidence in either type of culture. The main WSSV protective factors were feeding with plankton, high mangrove to pond area ratio, green water shrimp culture technique, ploughing of pond bottom, and dominance of the yellow *Vibrio* colonies over the green ones.

Farmers are recommended to adapt the green water system for shrimp culture and to replant mangroves in areas receiving pond effluents not only for disease prevention, but also for a more sustainable environment.

Effect of Biogen® as a probiotic supplier in microdiets for *Penaeus japonicus* post larvae

T.S. ABDELKADER^{1,3}, A.Y. EL-DAKAR¹, G.D. HASSANEN¹, S.I. GHONEIM²

1. Dept of Fish Resources and Aquaculture, Faculty of Environmental Agricultural Sciences, Suez Canal University, El Arish, Egypt; 2. Dept of Food Sciences and Technology, Faculty of Environmental Agricultural Sciences, Suez Canal University, El-Arish, Egypt; 3. Dept of Laboratory Animal Medicine, Faculty of Veterinary Medicine, Seoul National University, South Korea. Email: tamersaid1977@hotmail.com.

The aim of this study was to evaluate the effect of different levels of Biogen® as a probiotic which contains benefit bacteria *Bacillus subtilis* and some digestive enzymes on growth performance and food utilisation of *Penaeus japonicus* post larvae. Micro diet technique was used to prepare a basal diet containing approximately 50 % protein, and experimental diets with three different levels of Biogen® (0.1, 0.2, 0.3% and the control 0.0%). Four circular conical bottomed fiberglass tanks in triplicate were used. Every tank supported with source of fresh marine water and clear air. After 30 days all post larvae fed Microdiets containing Biogen® gave higher survival rate, weight gain, growth index and total length with a significant difference ($P < 0.05$) from the control. Furthermore, use of Biogen® increased palatability and food intake for the diets. There were significant differences ($P < 0.05$) between the Biogen® treatments and with the control except in FCR and PER. The optimum level of Biogen® to *Penaeus japonicus* post larvae was 0.2%.

Keywords: nutrition, microdiets, shrimp, post larvae, probiotics

Study on the activities of digestive enzymes of juvenile Chinese sturgeon (*Acipenser sinensis* Gray) during seawater adaptation

XUGANG HE¹, CONGXING XIE¹, PING ZHUANG²

1. Fisheries College, Huazhong Agricultural University, Wuhan 430070, China; 2. East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, 300 Jun Gong Road, Shanghai, 200090, China.

The aim of this work was to determine the effects of salinity on the digestive enzymes activities in Chinese sturgeon *Acipenser sinensis*. Seventy-two Chinese sturgeon juveniles (8 months old, domesticated broodstock) were obtained from Institute of Chinese sturgeon, China Gezhouba Co. Corporation, and transferred to the Aquaculture Laboratory East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Shanghai, China)

by air. The fish were acclimated for 15 days in freshwater and then were randomly divided into two groups. One group was reared in freshwater (0.5‰, 46 mOsmol kg⁻¹, plasma hyposmotic medium, control group), and the other one was transferred directly to salt water at 10‰ (10‰ SW, 273 mOsmol kg⁻¹, plasma isosmotic medium) which was obtained by diluting seawater at 37 ‰ with dechlorinated tap water. The digestive protease, amylase, and lipase activity in Chinese sturgeon were measured at 3, 12, 24, 72, 216 and 480 hrs after transfer to 10‰ SW and compared with that of freshwater control group. The protease, amylase and lipase activities in the alimentary canal of Chinese sturgeon increased in the first hours after exposure to 10‰ SW, and then decreased rapidly, to the original level. Protease and amylase activities began to increase in the first hour after transfer, and decreased rapidly, reaching minimum at 12 hours, returned to basal level at 216 hours, while the control group maintained basal levels. The minimum activity of lipase occurred at 24 hours, and increased continually from 72 hours, reaching the basal level at 216 hours, while the control group maintained basal level. The activity of lipase was affected strongly by salt. Environment salinity did not affect the secretion of digestive enzymes in the liver. It needs 9-20 days for Chinese sturgeon to adapt to isosmotic environment from a hyposmotic environment and ultimately depends on its capacity to regulate digestive enzymes system.

Keywords: Chinese sturgeon (Acipenser Sinensis), digestive enzymes activities, seawater adaptation

P-068

Feeding behaviour and social structure of rainbow trout (*Oncorhynchus mykiss*) in relation to one or two feeding deliveries in artificial streams

MOHAMMAD SAEED HEYDARNEJAD

Aquaculture Sector, Biology Department, Faculty of Science, Shahrekord University, POB 115, Shahrekord, Iran. Email: msh@utas.edu.au.

The aim of this study was to investigate feeding behaviour and social structure of rainbow trout (*Oncorhynchus mykiss*) in two raceways (Th1 and Th2) acting as artificial streams. Food for fish was restricted to two feeding periods in one location in Th1 (upstream) and in two locations (up-and downstream) in Th2. To increase cost of obtaining food by the fish, one to three partitions were applied in the raceways. The results show that feeding locations are able to influence the fish spatial distribution and social structure of the fish so that the fish respond to these reward sites in order to maximise their foraging behaviour. The rate of agonistic interactions between the fish before the mealtimes was high, in particular in Th1 than Th2 fish due to an extra place of food delivery in Th2 treatment and therefore less competition for food in this raceway, than to Th1 fish.

Keywords: Rainbow trout; Sociality; artificial streams.

Feed utilisation and growth in response to cell-bound phytase of *Pichia anomala* on *Labeo rohita* (rohu)

I.J. SINGH, GRISHMA TEWARI

Department of Fishery Biology, College of Fisheries, B. Pant University of Agriculture and Technology, Pantnagar-263145, India. Email: singhij2@gmail.com.

The present investigation was carried out to evaluate the effect of cell-bound phytase of the yeast, *Pichia anomala* on protein digestibility, feed conversion ratio, phosphate and ammonia excretion levels and growth in an extensively cultured freshwater fish, *Labeo rohita* (rohu). Comparison between effects of cell-bound phytase and pure phytase enzyme on above aspects were also assessed. In experiment I, feeding of fingerlings of *L. rohita* was done with yeast biomass @500, 1000 and 1500U cell-bound phytase/kg feed in triplicate glass aquaria for 90 days. In experiment II, fingerlings of *L. rohita* were given feed supplemented with phytase enzyme and yeast biomass phytase @1000U/kg feed and equivalent deactivated yeast biomass without phytase activity. Feeding trials were also carried out using yearling *L. rohita* with yeast biomass phytase @500, 1000 and 1500U/kg feed and phytase enzyme @1000U/kg feed in 10m² cemented tanks for 90 days. Again feeding trials using yeast biomass phytase and phytase enzyme @1000U/kg feed were carried out in 25m² cemented tanks for 75 days and comparisons were made between performances by *L. rohita* in 10m² and 25m² cemented tanks after being fed with yeast biomass phytase @1000U/kg feed.

Feeding of fingerlings of *L. rohita* with yeast biomass phytase @500, 1000 and 1500U/kg feed for 90 days showed better growth performance with highest apparent protein digestibility (APD) and feed conversion ratio (FCR) and lowest phosphate (PO₄-P) and NH₄-N excretion at the level of 1000U yeast biomass phytase/kg feed. *L. rohita* fingerlings fed with @1000U yeast biomass phytase, equivalent deactivated yeast biomass without phytase activity and 1000U phytase enzyme/ kg feed for 45 days showed comparable response to 1000U yeast biomass phytase. These observations showed that most appropriate phytase supplementation level of yeast, *P. anomala* biomass phytase for *L. rohita* is @1000U/kg feed. The field trials carried out with yearlings of *L. rohita* in 10m² (90 days) and 25m² (75 days) cemented tanks showed that the yeast biomass phytase @1000U/kg feed gave better results compared to 500U or 1500U biomass phytase or 1000U phytase enzyme, and performed better in 25m² tanks.

Utilisation of barley bran, olive mill and date stone added formulated feed by tilapia (*Oreochromis niloticus*) fingerlings

KERI ALHADI IGHWELA^{1,2}, MAHMOUD A.A. METWALLY¹, AMBOK BOLONG ABOL-MUNAFI²

1. Department of Biology, Faculty of Arts and Science, Al-Mergab University, Libya;

2. Institute of Tropical Aquaculture, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia.

Email: kerigwallah@yahoo.com.

A study was conducted on the effects of waste materials in formulated diets on the growth and various blood parameters (blood sugar, total protein) of Nile tilapia (*Oreochromis niloticus*). Four isocaloric diets containing 30% different waste sources, diet 1 (control) contained wheat bran, diet 2 contained barley bran, diet 3 contained olive mill and diet 4 contained date stone, were formulated and tested on tilapia fingerlings (mean weight 34.53 g) for 12 weeks. The results could be summarised as follow: Growth rate, the highest weight gain percentage was obtained in fish grown on diets 2 and 3, but food conversion ratio was low feeds, and protein efficiency ratio of fish fed the diet 4 were the lowest among all groups. The blood sugar concentration showed a higher increase in group 3 compared to groups 2, 4. Total protein in blood serum showed no significant difference in all groups, but the lowest value was in fish fed diet No. 4. These results indicate that Nile tilapia can utilise barley bran, olive mill and date stone without retardation.

Keywords: barley bran, olive mill, date stone growth performance, blood sugar, protein

Evaluation of optimum dietary protein to energy ratio and its effects on molting, growth, precocity, enzyme activity and chemical composition of juvenile Chinese mitten crab *Eriocheir sinensis*

XIAOWU LI^{1,2}, JIASHOU LIU¹, ZHONGJIE LI¹, TANGLIN ZHANG¹, FENGYUE ZHU¹

1. State Key Laboratory of Freshwater Ecology and Biotechnology, Institute of Hydrobiology,

Chinese Academy of Sciences, Wuhan, 430072, P.R. China; 2. Graduate University of the

Chinese Academy of Sciences, Beijing, 100000, P. R. China. Email: jslu@ihb.ac.cn.

A 76-day growth experiment was conducted to determine the optimum dietary protein to energy (P/E) ratio and its effects on growth, precocity, enzyme activity and chemical composition of juvenile Chinese mitten crab *Eriocheir sinensis* (initial weight, 9.92 ± 0.25 g). Six practical diets were formulated to contain three main protein levels (32%, 35% and 40%) with similar lipid (6.88~7.39%) and energy levels (18.37~20.25 kJ/g). The P/E ratio ranged from 15.94 to 21.25 g protein/MJ gross energy (g/MJ). Broken-line regression or polynomial

regression analysis was used to determine the optimum P/E ratio for the best response. The results showed that the specific growth rate in weight from the beginning to the first molting (SGRw0-1), from the first molting to second molting (SGRw1-2) and from the beginning to the second molting (SGRw0-2) was significantly affected by dietary P/E ratio ($P < 0.05$). The specific growth rate in body weight (SGRw) and carapace width (SGRcw) for the whole experiment period was not affected by dietary P/E ratio ($P > 0.05$). The optimum diet P/E ratio for juvenile *E. sinensis* in terms of SGRw0-1, SGRw1-2, SGRw0-2, SGRw and SGRcw was 18.64, 19.20, 19.17, 18.93 and 18.71 g/MJ, respectively. Molting frequency and survival rate were significantly affected by dietary P/E ratio ($P < 0.05$). Precocious rate decreased with increasing dietary P/E ratio and reached the lowest value at 19.07g/MJ, and then increased with increasing dietary P/E ratio, but there was no significant difference between groups ($P > 0.05$). Based on precocious rate, the optimum dietary P/E ratio for juvenile *E. sinensis* was 18.47 g/MJ. The activity of alkaline phosphatase, trypsinase and steapsin was significantly affected by dietary P/E ratio ($P < 0.05$). Chemical composition of crab body was significantly affected by dietary P/E ratio ($P < 0.05$). According to the results, we recommend 19.20g/MJ as the optimum diet P/E ratio with 35.77% protein for juvenile *E. sinensis*, based on SGRw1-2.

Keywords: P/E ratio, molting, growth, enzyme activity, precocity, chemical composition, Chinese mitten crab

P-072

Effect of a new formulated diet based on terrestrial vegetables on roe yield and quality in the sea urchin *Paracentrotus lividus* (Lin 1816)

LUCA MICCICHÈ, PAOLO SCARIANO, ALBERTO FALCONE, SALVATRICE VIZZINI, ANTONIO MAZZOLA

Laboratory of Marine Biology, Dept of Ecology, University of Palermo, via Archirafi 18, 90123 Palermo, Italy

In the Mediterranean the increase of market demand for the sea urchin *Paracentrotus lividus*, the roe of which is a delicacy, has transformed a small scale fishery carried out by a limited number of fishers with a product destined for local consumption, to an industrial and often an illegal fishery. This has reached locally very intense levels, inducing over-exploitation of natural stocks. All these factors prompted the development of culture methods to reduce excessive dependence on natural stocks. One of the principal aims is still to formulate a diet that can determine the improvement of sea urchin roe.

In the last years, in aquaculture, there has been an increasing tendency to use proteins derived from terrestrial vegetables rather than marine organisms for feed formulation. While sea urchins are predominantly grazers on macroalgae, the use of macrophytes for large-scale commercial culture is unlikely to be commercially viable, due to the temporal variation in quantity of algae. Instead the advantage of the constant availability of terrestrial

vegetables makes of great interest the use of these vegetables in the formulation of artificial diets.

The principal aims of this study were, therefore, to appraise the potential use of terrestrial vegetables in the formulation of an artificial diet for the culture of the sea urchin *P. lividus* and to assess roe growth and quality in terms of lipid, protein and carbohydrate content.

In the first feeding experiment, a stock of wild *P. lividus* was reared in controlled conditions for three months. Sea urchins were fed ad libitum twice a week for three months with three typologies of terrestrial vegetables (*Lactuca sativa*, *Beta vulgaris*, *Brassica oleracea*) and the seaweed *Ulva lactuca*. At the beginning and at the end of the experiment, biometric variables and parameters (roe wet weight, gonadic index and total body weight) were measured and lipid, protein and carbohydrate content in the roe was analysed. The results showed that both *L. sativa* and *B. vulgaris* had a positive effect on sea urchin growth, causing an increase in roe wet weight and gonadic index, but organoleptic characteristics were not maintained.

Once selected the terrestrial vegetables that had led to the best performance in terms of roe biomass (i.e. *L. sativa* and *B. vulgaris*) were used in the formulation of an artificial diet in which fish proteins were drastically reduced. In a second feeding experiment sea urchins were fed for three months with the artificial diet, while control organisms were fed with macroalgae. At the end of the experiment the artificial diet resulted in an excellent growth performance of roe (weight, 4-6 g per urchin, was 3 to 5 times higher than in control sea urchins). In addition, during the experiment roe preserved the organoleptic characteristics, in terms of taste, colour and texture and improved their quality with an increase in lipid, protein and carbohydrate content.

P-073

Production of artificial fish feed using locally available ingredients in Namibia

ELIZABETH NDIWAYELE¹, MD. GHULAM KIBRIA², JAVIER QUEVEDO RUIZ¹

1. *Omahenene Inland Aquaculture Centre (OIAC), North West Region, MFMR-Namibia;*
2. *Commonwealth/MFMR-Namibia. Email: nanghai1980@yahoo.com.*

Fish is an important source of food and income generation for many people in Africa. Tilapias are widely farmed and dominate the aquaculture production in Africa. Among other species, three spot tilapia, *Oreochromis andersonii* and catfish, *Clarias gariepinus* are some of the species which have been raised in ponds and reservoirs in the northeast and northwest zone of Namibia for self-consumption or local sales. Most fish species such as catfish and tilapia requires high protein content for fast growth under controlled culture systems. Since high protein containing feed (commercial fish feed) is expensive, studies are being considered to produce high-quality, low cost fish feed that will yield in better fish

growth rate. Since extensive and semi-intensive tilapia and catfish culture are becoming more popular in Namibia, particularly in the north and northwest of the country, economically feasible diets need to be produced using local ingredients such as maize (zear mays), Mahangu (pearl millet) (*Pennisetum glaucum*), wheat bran- a by-product of wheat (*Triticum aestivum*) and fishmeal (mainly horse mackerel). The inclusion of these local seeds/ ingredients into fish feed will not only promote fish growth, but also can boost commercial trade and provide an additional opportunity for employment generation and means of income to small scale land farmers.

An experimental trial was carried out to assess the growth performance of juvenile tilapia when fed on locally produced feed at different protein levels. Three spot tilapia (*Oreochromis andersonii*) fingerlings of mixed sex with mean weight of $6g \pm 0.25$ were stocked in cages at a density of $55/m^3$ (500 fish per cage). Cages measuring $9 m^3$ ($3 \times 3 \times 1$) were fixed in an earthen pond of $300 m^2$ and 1.5 m depth for three months, from September to December 2008 at Onavivi Inland aquaculture Centre (Namibia). Fish were fed on at different protein levels 15%, 20% and 25% Crude protein (CP) as treatments. All treatments were fed at 5% body weight, twice a day. Treatments were replicated two times. Significant differences ($P < 0.05$) in mean weight amongst treatments were observed. The highest final weight gain was noted for the local 25% CP diet with average weight of 27.3 ± 0.21 followed by diet 20% CP with 25.02 ± 0.07 and 15% CP with 24.81 ± 0.11 and the lowest final weight was observed in the control diets (25% CP) with 22.61 ± 0.23 g respectively. The final weight gain from diets 20% CP and 15% CP did differ significantly ($P > 0.05$) but were significantly different ($P < 0.05$) from that of diet 25% CP. On the other hand, the control diet 25% CP had the highest production cost of N\$6.13/kg followed by the local diet 25% CP with N\$3.48/kg, 20% CP with N\$2.99/kg and the lowest production cost of N\$2.5/Kg was observed from diet 15% CP. Specific growth rate (SGR), and Increased weight gain (IWG) was also higher for the local diet of 25 % CP as compared to the other diets. The trial concluded that locally produced fish feed from available ingredients showed the potential for fish growth at an affordable production cost (1U\$ = 7.5 N\$ (Namibian dollar)).

Keywords: Namibia, fish feed, production, three spot tilapia, cage, semi intensive

The onset of exogenous feeding in relation to sensory organs and behavioural development of *Mystus nemurus* larvae

SHARIFAH RAHMAH¹, SHINJI YAMAMOTO¹, YOSHIZUMI NAKAGAWA¹, KEITARO KATO¹, SHIGEHARU SENOO², OSAMU MURATA¹

1. Fisheries Laboratory of Kinki University, Shirahama Experiment Station, Kinki University, Japan; 2. Borneo Marine Research Institute, Universiti Malaysia Sabah, Malaysia.

Bagrid catfish, *Mystus nemurus* has been a favourite freshwater fish in Southeast Asia owing to its excellent taste and consists of white textured and non-bony flesh. It contains high protein, vitamin E and polyunsaturated fatty acids. In this regards, *M. nemurus* has become a new aquaculture candidate, hence the aggressiveness in culture attempts with higher retail price compared to *Clarias gariepinus* and *Pangasius hypophthalmus*. Nevertheless, lower survival, growth and higher deformity of artificially produced larvae have been the bottleneck in successful mass production of *M. nemurus*. This is attributed from improper first exogenous feeding time. As the ability to locate and capture prey rely extremely on sensory organs especially at the early larval stage, this study elucidate the onset of first exogenous feeding based on the readiness of the eye, inner ear, taste buds and olfactory organ which were then correlated with the changes in behaviour.

Artificial fertilisation was conducted using a pair of brood fish with intraperitoneal hormonal injection of 0.5 ml/kg ovaprim for female and half the dosage for male. Newly hatched larvae were cultured in an 80 L rectangular recirculatory glass aquarium with stocking density and temperature of 30 larvae/L and 28-29°C, respectively. Development of sensory organs such as eye, inner ear, taste buds and olfactory organ were observed through histological analysis from 0 to 36 hours post hatching at 6 hour intervals. These developments were correlated with its behaviour to determine the onset of exogenous feeding for *M. nemurus* larvae.

Sensory organs were immature in newly hatched larvae with unpigmented eyes, oval-shaped otic vesicle with two otoliths, unapparent taste buds and an undeveloped olfactory organ. The larvae lye scattered at the bottom of the tank either in upright, inverted or sideways position with lashing movement of the tail and were incapable of feeding. As the behaviour changed with development of the sensory organs, first feeding was observed between 30 to 36 hours post hatching when the larvae portrayed schooling and foraging behaviour at the bottom of the tank. At this stage, the eyes were deeply pigmented with visible optic nerve. The retina differentiated into six layers with single cone cells at the outer nuclear layer. Protrusion of the semicircular canals into anterior vertical, horizontal and posterior vertical sections provided balance and horizontal swimming behaviour. Taste buds were apparent on the barbels, mouth edge, inside the mouth and gill arches. Sensory epithelium of the olfactory organ thickens into ciliated lamella. Following the readiness

of sensory organs and behavioural development, we concluded that the onset of first exogenous feeding for *Mystus nemurus* larvae was between 30 to 36 hours post hatching where S-type *Brachionus* sp were consumed.

P-075

Water stability of formulated diets incorporated with water hyacinth for Nile tilapia, *Oreochromis niloticus*, fingerlings

MUBARAK EISA A-RAHMAN, TIBIN AMBOK BOLONG, AMIN MAT AMIZA, KHODA BAKHSH HAMID

Faculty of Agrotechnology and Food Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu Darul Iman, Malaysia. Email: tbin33@yahoo.com.

A water stability test was conducted on a balanced formulated diet (on dry basis) incorporated with different levels (0%, 10%, 15%, 20% and 25%) of powdered fresh water hyacinth (WH) *Echhornia crassipes*, to determine percentage leaching of dry matter (LDM) of the prepared pellets in gradual replacement of wheat flour to be fed to Nile tilapia (*Oreochromis niloticus* L.), fingerlings, using horizontal shaking method at 29 °C/6 hrs. The mean loss of the dry matter after 6 hrs of pellet immersion was 17.3% LDM, 17.7% LDM, 18.3% LDM, 19.5% LDM and 22.1% LDM for the reference diet (with 0% WH), diet 1 (with 10% WH), diet 2 (with 15% WH), diet 3 (with 20% WH) and diet 4 (with 25% WH), respectively. There is no significant difference between leaching stability of the reference diet and trial diets 1, 2, and 3. Diet 4 showed the highest degree of dry matter loss. However, incorporation of WH in Nile tilapia fingerling diet might be possible up to 20% in powdered fine form.

Keywords: pellet water stability, incorporated water hyacinth, tilapia fingerling

P-076

Fish protein hydrolysates and their potential applications

MUSTAFA ÜNLÜSAYIN, RUHAN ERDILAL

*Akdeniz University, Faculty of Fisheries, 07059-Campus, Antalya, Turkey.
Email: munlusayin@akdeniz.edu.tr.*

Fish muscle is a very good nutrition source because of its high nutritious value and bioactive compounds for biomedicine. These bioactive compounds are amino acids, peptides, terpenoids, steroids, enzymes, alkaloids, fatty alcohol esters and glycolipids. These can be extracted using various technologies. Enzymatic hydrolysis of fish-raw material offers a rapid and reproducible method for the separation of soluble and insoluble peptide fractions, bones and oils from complex matrices with commercial proteases. Enzymatic hydrolysis

is a viable option because it avoids the extremes of chemical and physical treatments and thus minimises undesirable reactions which could destroy valuable components in proteins. Protein hydrolysates or peptides have health-related functions such as blood pressure reduction, antioxidant and antimicrobial function. In addition, the enzymatic protein hydrolysates obtained are composed of free amino acids and short chain peptides exhibiting several advantages in functional properties such as improved solubility, heat stability, water binding ability and increased nutritional quality. Such hydrolysates have a range of potential applications for foods (foaming, whipping, and emulsifying agents, flavour agent after debittering, formulas for hyper allergic infants) and nutraceuticals (sports nutrition) and also for pharmaceutical (bioactive peptides) and biotechnological applications (peptone ingredient in microbial growth media). Hydrolysates (soluble concentrate) can also be useful for aquaculture uses and animal feed. In recent years fish protein hydrolysates from muscle or fishery by-products has been investigated as a source of promising health benefit molecules. In this review, we have focused on the hydrolysis of fish muscle and by-products and their potential applications.

P-077

Influence of dietary phosphorus levels on growth performance, body composition, and the serum biochemical indicators of juvenile *Pelteobagrus fulvidraco*

C. WANG¹, Q. LIAO², J. ZENG¹, L. XU¹, Q. SHENG¹

1. The Fisheries College, Huazhong Agricultural University, Wuhan, Hubei, China 430070; 2. Yueyang Zhanxiang Biological Science and Technology Corporation, Yueyang, Hunan, China. Email: cfwang@hzau.edu.cn.

In order to reduce the phosphorus content in the effluent and adjust the phosphorus content in artificial feeds for aquaculture, a trial was conducted to estimate the effects of dietary phosphorus levels on growth performance, whole body composition, and serum biochemical indicators of juvenile yellow-headed catfish (*Pelteobagrus fulvidraco*). Three extruded diets (commercial yellow-headed catfish diet-based) were formulated to contain $\text{Ca}(\text{H}_2\text{PO}_4)_2$ levels at 25, 15, and 5 kg per tonne of diet, respectively. Each diet was fed to triplicate groups of 15 fish (initial average BW of 3.2 g) over 4 weeks. At the end of the trial, specific growth rate (SGR) and weight gain (WG) of the fish fed with the diet containing 15 kg of $\text{Ca}(\text{H}_2\text{PO}_4)_2$ /t was significantly higher than the other groups ($P < 0.05$). Body crude protein content of the fish fed with the diet containing 25 kg of $\text{Ca}(\text{H}_2\text{PO}_4)_2$ /t had increased significantly compared with those fed the diet containing 5 kg of $\text{Ca}(\text{H}_2\text{PO}_4)_2$ /t ($P < 0.05$), whereas both of them did not differ significantly between 15 kg of $\text{Ca}(\text{H}_2\text{PO}_4)_2$ /t treatment groups ($P > 0.05$). Serum superoxide dismutase (T-SOD) of the fish fed the diet containing 15 kg of $\text{Ca}(\text{H}_2\text{PO}_4)_2$ /t was significantly higher than the other 2 dietary treatments ($P < 0.05$). There was no significant difference in alkaline phosphatase (AKP), calcium, and phosphorus in serum among 3 dietary treatments ($P > 0.05$). The results suggested that

phosphorus content in the current commercial feed for juvenile yellow headed catfish could be reduced from 25 to 15 kg of $\text{Ca}(\text{H}_2\text{PO}_4)_2$ /t, and the growth performance, body composition, and immunity of this fish would not be diminished.

Keywords: Pelteobagrus fulvidraco, dietary phosphorus, growth

P-078

Improving food security through aquaculture

NALAN GOKOGLU, PINAR YERLIKAYA

Akdeniz University Fisheries Faculty Antalya, Turkey. Email: ngokoglu@akdeniz.edu.tr.

Global warming and world's economic crises trigger the concern of food shortage and starving. In a few weeks without food, the body will use its own fat and muscle for energy. World population numbers are on track to reach 7 billion in 2011, even 12 years after reaching 6 billion in 1999. The most challenging struggle of the modern civilisation is supplying food satisfactorily for increasing population. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food security is not a food production or food aid; it is a fundamental human right. Especially, poor countries lose their productive, competitive, and sustainable properties of agricultural sector and there is no chance to enlarge soil for culture. The fact that, $\frac{3}{4}$ of the world is covered by water, should be considered. Usage of aquatic sources will contribute quality, variety and abundance of food supply. Aquatic products provide adequate and balanced diet; meet the demand for high-value animal protein, combat malnutrition and under-nutrition. Aquaculture is cultivating aquatic populations under controlled conditions and a way of catching fish to feed the growing population, providing alternative livelihood products. Natural fish stocks are heavily depleted and continuing to be over-exploited. Aquaculture is helping to compensate for losses due to deterioration of conventional capture fisheries and fight for limited sources. Consumption of fish is increased directly with aquaculture. The proportionate contribution of aquaculture to food fish consumption approximates 45 percent. Local food supplies can be improved through the increased availability of low-cost fish. Many people are directly employed in aquaculture sector. Therefore, aquaculture is considered direct and indirect food security. The poor can access to the increased supplies of fish and that they can enhance their aquaculture-derived income. Aquaculture investments are economically feasible. Small-scale aquaculture producers can increase their household incomes with minor investments. They also have chance to obtain inadequate access to food for themselves. Aquaculture improves food security in many ways such as consumption and income. It reduces poverty, increases welfare of low-income. Natural fish resources need to be managed to restore and make sustainable. It is important to obtain food security and pass on the natural heritage to the future.

Fisheries cooperative-based lake restoration in Nepal

TEK BAHADUR GURUNG, AGNI NEPAL, SURENDRA PRASAD

Nepal Agricultural Research Council, Fisheries Research Station, Pokhara, Nepal.

Email: tek_fisheries@hotmail.com.

Nutrient and organic load, sedimentation, overgrown water plants, succession, encroachment, absence of authoritative institutions of management are some of the inherent problems associated with smaller lake (≤ 500 ha) degradation. Restoration of lakes is mostly labour intensive, lengthy, and costly; however, could be beneficial as that might return precious resources. Recently, a small lake degraded by sedimentation, exploitative growth of aquatic weeds and encroachment has been successfully reinstated: as an initiative of the restoration process. It has been argued for stimulating the sustainable co-evolution of human activities in relation to lake restoration communities located in shoreline should be involved. There are few studies illustrating stimulation of human activities in relation to lake restoration sustainably. Therefore, we examined if fisheries based cooperative management can restore the degraded Lake Rupa of approximately 100 ha in area in mid hills of Central Nepal. For the purpose a fisheries cooperative was established in year 2002 with the main aim of lake restoration through inclusive community management. The cooperative undertook several strategies to restore the lake ecosystem such as weed removal, fish stocking enhancement and recapture practices. As a result encroachment halted, unwanted weeds controlled and dominance of phytoplankton over macrophytes restored. Moreover, lake water quality improved with substantial increase in dissolved oxygen and consistency in transparency in water column. Capture fish yield revived and reached about 60 t in 2008 from 5 t in year 2001. With increasing income more focus was given on lake cleaning, watershed management, livelihood enhancement and other social activities. At present, the members involved in the cooperative reached 693 families with 19 permanent employees. Several primary and high schools, NGOs and social organisations are direct beneficiaries of the cooperative. The cooperative has entered in its 8th years of its establishment successfully. The present approach of lake restoration can be applied in several smaller lakes especially located in poverty laden areas suffering from eutrophication, sedimentation, encroachment including climate change and other environmental degradation. It is expected that present fisheries cooperative model of lake restoration can restore thousands of degraded, shrunken and encroached lakes especially in developing countries as cooperative provides institutional, social and financial strengths to conserve lake resources in sustainable manner.

Keywords: Cooperatives, lake restoration, inclusive community management, fish yield

Economic and social importance of aquaculture in Europe

G. GYALOG, E. BÉKEFI, L. VÁRADI

Research Institute for Fisheries, Aquaculture and Irrigation (HAKI), Anna-liget 8, H-5540 Szarvas, Hungary. Email: gyalog@haki.hu.

The total gross value added of the European aquaculture sector was around 4.1 billion USD (45-50 percent of the total production value) in 2008, accounting for 0.02 percent of the continent's GDP. This data sheds some light on the relatively minor economic importance of aquaculture in Europe, especially compared to Asia, where its contribution to GDP in some populous countries (Vietnam, Bangladesh, China, Philippines) amounts to 0.5-3.0 percent. Furthermore, the relative weight of aquaculture in the European economy has been decreasing in the latest years because the sector has not been able to keep pace with the overall economic growth of the region. The social importance of aquaculture is also negligible in Europe on a continental level, as approximately 120,000 people employed in the sector, only 0.03 percent of the total employment. However, aggregate economic and employment statistics hide huge regional and subsectoral differences.

High-profile aquaculture subsectors, like salmonid and seabass/seabream farming play a significant economic role in some parts of Europe. In the Faroe Islands salmon farming accounts for 4.3 percent of the GDP and 2.2 percent of the total employment. The Faroese export is heavily dependent on aquaculture, farmed salmon and trout represent more than 20 percent of the total export in terms of value. In Norway (representing 33.7 percent of the production value of European aquaculture) salmon and trout culture accounts for 0.28 percent of total GDP, 0.2 percent of total employment and almost 2 percent of total export. Some of its coastal regions are dependent on aquaculture, salmonid farming make up 2 - 3 percent of the GDP in five counties. Seabass and seabream farming is a significant contributor to the Greek economy, representing 0.11 percent of the GDP and more than 1 percent of the total export. However, it must be noted that in contrast to the relatively high economic weight of salmonid and seabream/seabass farming, these high-profile subsectors are not so significant employers in the national and regional economies; their contribution to employment is lower than to GDP. This fact is reflected by the extraordinary high labour productivity of these subsectors (75,000–250,000 USD value added per employee in the above mentioned countries), resulting from the automated technology.

Although extensive aquaculture like traditional carp and shellfish farming is of negligible economic significance, its social role is high in some Atlantic regions. The small-scale mussel farming accounts for more than 3 percent of total employment in a Portuguese region, and in some Spanish and French regions its contribution to total employment is 0.2–1.1 percent. In Eastern Europe extensive pond culture is also very labour intensive, providing an important source of income to rural communities in some poor regions. Labour

productivity is considerably lower in these traditional aquaculture subsectors; generally the value added per employee is under 10,000 USD. In other words, extensive fish culture offers more jobs per unit production compared to high-profile subsectors.

P-081

Factors effecting livelihood capabilities and diversification of shrimp farmers in a region of the Mekong Delta, Vietnam

TRAN THI PHUNG HA

1. Department of Sociology, School of Social Sciences and Humanities, CanTho University, Vietnam; 2. Law and Governance Group, Department of Social Sciences, Wageningen University, Netherlands.

Shrimp farming is a major livelihood activity in the Mekong Delta, southernmost of Vietnam, which has been promoted by government aiming to reduce poverty, provide employment opportunities and increase exports to support economic development. The shrimp farming system, however, is economically risky and may cause negative impacts on the environment, and hence impact on livelihoods of local people. A study was undertaken between January and August 2008 in three provinces of the Delta, Bac Lieu and Ca Mau, to identify household assets of different social groups, and to examine the effects of rapid expansion of shrimp farming on the rural livelihoods. A participatory approach was applied through consultations and discussions with a wide range of stakeholders before focusing at household level through structured interviews. The economic and livelihood characteristics of 138 farms were analysed using cluster analysis of variables emerged from the surveys of four household types involved in shrimp farming: (1) improved extensive non-forest, (2) mixed mangrove-shrimp, (3) intensive and (4) clustered intensive. The paper aims to identify the imbalanced accessibilities to livelihoods among four shrimp farming groups and among different well-off status and to highlight the factors that threaten the poor and benefit to the well-off as well as to emphasise the risks that lead people to change livelihoods in diversification processes.

All shrimp farmers are threatened by unstable shrimp markets, a fierce market competition and the high quality requirement in the global market, but accessibilities to capitals and vulnerability were different among the 4 groups. People in mangrove-shrimp system had reduced land entitlements and difficulties to acquire “know-how”. Mangroves contribute to higher profits per hectare compared to the intensive shrimp systems that were also exposed to more regular shrimp failure. Shrimp farmers adapted to the risks by diversification: redesigning farms, producing salt, changing type of shrimp; involving in social organisations, integrating aquaculture and agriculture, and farming shrimp by organic standards for higher prices. The rich diversified through wealth accumulation but the poor diversified to survive in the context of declining access to resources.

Mariculture site and species cultured in SE-Sulawesi, Indonesia

WA IBA¹, HATIM AL BASRI², LA ODE M. ASLAN³, HOTMAN HUTAURUK, ARMEN ZULHAM, GEOFF GOOLEY, SENA S. DE SILVA

Aquaculture Section, Fisheries Department Faculty of Fisheries and Marine Science Haluoleo University. Email: icharyr@yahoo.com, hatim@cria.indosat.net.id, aslaod66@yahoo.com.

Study survey was carried out at three regencies of SE Sulawesi, Indonesia to investigate cultured species and water quality condition at mariculture sites. Data obtained through questionnaires were analysed to draw market chain of mariculture commodities and identified problems faced by farmers. Site sampling was conducted to obtain site data and water quality parameters. The regencies include Kendari, Muna and Buton. The sampling locations were selected based on number of mariculture sites and their contributions to the economy of the community. Species cultured ranged from low to high value species. Low value species were represented by seaweed while high value species include groupers, sea cucumbers and spiny lobsters. Water quality parameters measured during the study include depth, dissolved oxygen, water clarity, temperature, TDS and salinity. Three big clusters of existing mariculture activities are located in Kendari, Muna and Buton areas serving both source of mariculture products and market destination or transit location. Long market chain was evident for all mariculture products. Most of fish farmers in Southeast Sulawesi are practicing traditional mariculture. Lacking financial support, knowledge skill, market information and assistance from responsible formal institutions have made these fish farmers difficult to increase their welfare through mariculture activities. Site capability and suitability analysis of existing or potential area of mariculture activities have rarely or never been looked by stakeholders involved in managing coastal area which result in crowded and unmanaged coastal area with multiple overlapping economic activities. All of surveyed locations of existing mariculture activities in Southeast Sulawesi show relatively optimal water quality condition.

The SUKRAN Project

In 2005 The Malaysian Government joined with Fish Protech Pty Ltd to develop small farm systems for use in Malaysia to reduce poverty in rural areas. The goals for each project were to give:

- A RM 300 monthly financial donation to 300 families below the poverty line.

- Create 40 direct and 40 indirect jobs for the local population.
- Produce 6 tonnes/week of high quality fish, A 20 year productive life for the farm.

Based on the above targets a Fish Protech licensed training farm was constructed in 2006. Training programs were developed and tested. Majutech, a new technology, was developed by Fish Protech and a Malaysian component manufacturing set up. Species selection and market testing was completed.

After this 3 year development program, in 2008 the Malaysian EPU allocated RM10 million each for the construction of 4 SUKRAN projects located in designated rural areas.

In June 2010 the first SUKRAN projects commence to provide the social - economic, employment, food security benefits they are created for.

Over the next 20 years each SUKRAN will provide total financial benefits amounting to RM 21.6 million for families, RM 60 million through buying local goods/services, RM 90 million from sale of fish.

P-084

Re-direction of culture-based fisheries management through institutional linkages: Sri Lankan case study

MOHOTTALA G. KULARATNE^{1,3}, CLEVO WILSON¹, SEAN PASCOE², TIM ROBINSON¹,
UPALI S. AMARASINGHE³

1. *School of Economics and Finance, Queensland University of Technology, Brisbane Australia;*
2. *CSIRO, Marine and Atmospheric Research, Cleveland, Brisbane Australia;*
3. *University of Kelaniya, Sri Lanka*

There is a great potential for secondary use of small irrigation reservoirs of Sri Lanka for the development of culture-based fisheries (CBF). However, current technical efficiency of CBF in these irrigation systems is only 44%. In the present study, we attempted to investigate the possible reasons for this low efficiency with a view to identifying appropriate remedial measures. The CBF development activities in village reservoirs in 1980s did not sustain due to various biological productivity-related problems such as lack of an effective means of selecting suitable reservoirs, lack of a guaranteed fingerling supply for stocking. Furthermore, weak institutional linkages, lack of legislation and poorly planned social mobilisation procedures also were responsible for unsustainability of CBF activities. Although some of these constraints, especially at the grassroots level have been overcome through concerted efforts of active researchers, the barriers at the institutional levels still prevail.

A national workshop and an international symposium held in Sri Lanka in 2003 and 2004, respectively have identified inadequate government legislation for water allocation for fisheries and agricultural activities in village irrigation systems as one of the main constraints to CBF development. Village irrigation systems are managed by farmer organisations (FOs) which are established under the *Agrarian Services Act (No 58 of 1979, No 4 of 1991)* and the *Agrarian Development Act of 2000*. There are legal provisions for various rural development activities through FOs, under the *Agrarian Development Act No 46 of 2000*, which include provisions for the development of CBF in village reservoirs. The community meeting held at the beginning of the rice cultivation season (Kanna meeting) is the major event that discusses reservoir water management in the village.

Members of FOs have well defined property rights for reservoir water uses for agriculture. However, user rights of water for CBF are not well-defined under any of the available legislations. In the Act 53 of 1998 and amendment Act No. 145 of 2006, which established the National Aquaculture Development Authority of Sri Lanka (NAQDA), there are no sufficient legal provisions to facilitate CBF or aquaculture development in irrigation reservoirs of the country.

A survey of 655 farming households in five administrative districts of Sri Lanka was carried out and according to results, 87% of the farmers have accepted that they receive the anticipated services from the Agrarian Research and Production Assistant (ARPA), the village level officer of the Department of Agrarian Development. Of them, 81% farmers were satisfied with the services of ARPA. The majority of farmers (77%) expected that CBF should be organised by the farmer community as a group activity with the help of relevant government officials. Based on these analyses, we identified two requirements for the development of CBF in village reservoirs. First, CBF must be legislated under Agrarian Services Act in order to solve the issue of water allocation between fish and rice farmers along with related issues on decision making while NAQDA involvement should be limited to scientific and technical support. Secondly, CBF should be organised as a co-management strategy where all stakeholders are involved in decision making processes.

Keywords: culture-based fishery, institutions, village irrigation systems

Feeding the world until 2050: scenarios, challenges and opportunities for sustainable aquaculture

DANIEL LEMOS¹, ALBERT G.J. TACON²

1. Marine Aquaculture Laboratory, Oceanographic Institute, University of São Paulo, São Paulo, Brazil; 2. Aquatic Farms, Kaneohe, Hawaii. Email: dellemos@usp.br.

Aquaculture has been filling the gap between global aquatic food consumption and outputs from wild stocks. This paper presents challenges and opportunities for sustainable food production via aquaculture related to population, territory, food and feed utilisation, and climate changes. Global human population is expected to increase from present 6.7 to at least 9 billion in 2050. Growth trends indicate regional distinction with differentiated increments in some regions (e.g. Sub-Saharan Africa). To cope with human demand in 2050 food volume may be 70% above present values and food accretion is necessary at equivalent rates for equitable access at global level. Increasing global population and consumption demand effective rise in food availability that includes improve utilisation efficiency of food resources in farming, processing and distribution chains. Aquaculture may consistently assist the offer for extra supplies of quality food in agreement with global perspectives. Produced volume may correspond to over 70% of aquatic food consumption of in 2050. On the other hand, sustainable supplies will depend on the ability of practices to cope with characteristics and availability of resources. Predicted trends in food production and use suggest the necessity to increment efficiency of nutrient source utilisation for human nutrition that may imply in progressive quality shift of raw materials for feeds. Thus, aqua feed manufacturing should not only avoid reliance on food-grade marine based sources but would also largely depend on lower grade raw materials (to be also improved by processing and/or biotechnological transformation) to fit as nutrient sources for farmed species. This variety of raw materials would further require strategic diversification in feed formulation and processing to allow manufacture flexibility according to availability and cost-benefit relationships. In addition, farming aquatic animals may achieve increased efficiency of nutrient and energy transfer from raw materials into aquatic meat, with <2.5 calories of feed per calorie of produced fish or shellfish compared to terrestrial livestock (4-7:1 in bovine, swine and poultry). Aquaculture can also play a role in adding quality food in relation to territory via terrestrial farming. Expansion as well as creation of new aquatic farming frontiers through responsible practices may be feasible in most countries through application of conventional species and rearing techniques. Freshwater farming in ponds and available water bodies has been confirmed as water-saving food production systems. Mariculture of plant, filtering and fed animals may be expanded over vast available coastal and even off-shore areas to produce several types of seafood. Moreover, the possibility of exploring the tri-dimensionality of water environment may provide additional efficiency for aqua-farming systems in available space. The recognition of the potentially changing climate and effects upon the environment will be also important in planning future development of aquaculture.

Local and regional surveys on potential vulnerability, resilience, adaptation and mitigation in farming areas are thus necessary including flexibility in species choice, rearing practices, scale and market relationships. Consistent supplies of aquatic food via aquaculture development could then be proposed in agreement with global changes at physical, human and resource dimensions.

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Aquaculture production in the ECOWAS sub-region: Nigeria as a case study

C.T. MADU, A. RAJI

National Institute for Freshwater Fisheries Research, P. M. B. 6006, New Bussa, Nigeria, W. Africa. Email: maduchuka@yahoo.com.

The Economic Community of West African States (ECOWAS), a sub-regional group of 15 West African countries was founded in 1975 with a mission to promote economic integrity for the self sufficiency of member nations. Nigeria as the headquarters of ECOWAS is also the leading country in aquaculture production with more than 85 per cent of the total fish production in the West African sub-region.

This paper reviews the 50 years of aquaculture development in Nigeria and the series of ups and downs the sector has passed through within the period. However, with the hosting of the NEPAD Fish For All Summit in Nigeria in 2005 a major public awareness and a great boost to aquaculture production were experienced. Annual fish production doubled from 43,950 tonnes in 2004 to 84,533 tonnes in 2006 and 85,087 in 2007. The private sector was the driving force while catfish farming was the motivating factor responsible for about 70 per cent of aquaculture production in the country.

The authors reviewed the aquaculture practices which centred on pond culture, homestead/backyard fish farming, integrated fish farming using poultry, pig or rice, cage culture in protected open waters, fish seed farming/fingerling production, commercial fish farming using water re-circulatory systems, cluster fish farming/fish farm estates. Marine, brackish water and shell-fish aquaculture are yet to be fully developed to meaningful production levels.

With over 16 million hectares of inland water surface area and flood plains available for aquaculture, the problems of aquaculture production in Nigeria were still enormous and were discussed to include – high cost and inadequate supply of good quality brood stock, fish seeds and fish feeds, inadequate fish storage, processing and marketing facilities leading to about 40 per cent post-harvest losses, difficulties in the access of affordable credit and insurance covers for aquaculture entrepreneurs, poor utilisation of the numerous water bodies available for aquaculture, poor perception of aquaculture production by policy makers and funding agencies and the need to recognise aquaculture as a fast growing

economy and a major source of food security, job creation and poverty reduction in the ECOWAS sub-region. Suggestions were made on how to improve aquaculture production in Nigeria and the ECOWAS sub-region in general.

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Aquaculture Treaty Settlement – providing for indigenous participation in sustainable aquaculture through a treaty settlement

NICHOLAS MANUKAU

Ministry of Fisheries, Auckland, New Zealand. Email: Nicholas.Manukau@fish.govt.nz.

Since the late 1980s, Maori (New Zealand's indigenous people) have gained transfers of commercial fishing assets and the legislative recognition of their non-commercial fishing rights and interests. The *Treaty of Waitangi (Fisheries Claims) Settlement Act 1992* gave effect to the settlement of both commercial and non-commercial fishing rights and interests. The use of coastal space for aquaculture was an important element missing from the initial fisheries claims settlement. This has since been settled through the enactment of the *Maori Commercial Aquaculture Claims Settlement Act 2005* (the 'Act'), where Maori are now provided with 20% of all new aquaculture space created in New Zealand.

One part of the poster briefly describes the settlement of Maori claims to commercial aquaculture space. The paper also describes the role of the Ministry of Fisheries administering the Act.

Part two of the poster outlines the difficulties faced by the Government and Maori to implement the Maori aquaculture settlement. To overcome these difficulties, the paper explains how Government and Maori worked collaboratively together to develop an innovative model of co-operation that led to a Deed of Settlement covering vast tracks of New Zealand's aquaculture space.

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Development and adoption of better management practices (BMPs) as the gateway to ensuring sustainability of small scale aquaculture and meeting modern day challenges

C.V. MOHAN

Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. Email: mohan@enaca.org.

The demand for quality and responsibly produced and certified aquaculture products is predicted to increase substantially in coming years and the most feasible, economical

and acceptable way to achieve these goals is for small scale farmers to adopt Better Management Practices (BMPs), collectively as a cluster, in a given locality. BMPs in the aquaculture context outline norms for responsible farming of aquatic animals. BMPs are management practices, and implementation is generally voluntary; they are not a standard for certification. Cluster management in simple terms can be defined as collective planning, decision making and implementation of crop activities by a group of farmers in a cluster through participatory approach in order to accomplish their common goal (reduce risks and maximise returns).

BMPs are not only commodity specific but also location specific. While developing BMPs, it is necessary to underpin the general principles for responsible farming that would cover environmental, social, ethical, food safety and husbandry issues. The first step in developing BMPs is identifying risk factors to the sustainability of the system using population based approaches. Interventions developed to address the identified risk factors can be referred to as better management practices. BMPs need to be pilot tested and validated before promoting adoption. Implementation of BMPs through a collective approach (cluster management) will help to achieve compliance with standards set by international agencies, certification bodies and trading partners.

NACA's experience with BMP promotion work in India, Indonesia, Thailand and Vietnam clearly suggests that BMPs improve yields, safety and improve quality of products taking into consideration animal health and welfare, food safety, environmental and socio-economical sustainability. Key BMP and cluster management work carried out in the region include (a) Shrimp project in India in collaboration with MPEDA and NaCSA, since the year 2000 and ongoing (b) shrimp work in Aceh under the ADB-ETESP project (2005-2009) in collaboration with FAO and IFC, (c) Mekong catfish work in Vietnam under the CARD program supported by AusAid (2008-2010) in collaboration with DPI, Victoria and RIA2 and CTU, Vietnam (d) WWF supported work in Thailand and India in collaboration with DOF, Thailand and MPEDA, India, respectively and (e) ACIAR supported work of strengthening networking and information sharing amongst BMP project implementers in the region. In addition NACA has also developed BMPs for the farming practices on Culture-Based Fisheries (CBF) in Sri Lanka, Vietnam and Lao PDR, under the auspices of ACIAR.

The regional BMP work of NACA has received a further boost with the support from the recently approved EU-ASM project under the 7th framework. In the EU-ASEM project an attempt will be made to assess the true holistic impact of BMP programs and develop practical and feasible strategies for national and regional scaling up of BMP and cluster management programs. Implementation of the BMPs will provide benefits to the farmers, environment and society.

Community-based extensive aquaculture on the flood plains of Guinea

TADASHI MURAI¹, SIBA TOUPOU², MACKY DIA², SACHIYO HANEDA³, SHUNJI SUGIYAMA⁴

1. JICA expert, Ouagadougou, Burkina Faso; 2. MFA, Conakry, Guinea; 3. Embassy of Japan, Conakry, Guinea; 4. JICA Technical Advisor, Tokyo, Japan. Email: t-murai@oafic.co.jp

In West African countries, many projects aimed at semi-intensive aquaculture promotion failed to produce sustainable impacts. MFA(5) and JICA(6) focused on the possibility of utilising numerous marshes on flood plains in highlands Guinea (N8°-11°, W9°-12°) for aquaculture which did not require significant inputs and high technical expertise. In 2005 pilot projects were initiated in order to field-test viability of the extensive aquaculture method in seasonal marshes.

Based on the concept that active participation of villagers is a key to sustainable implementation of aquaculture practices, villagers were requested to participate in the project from the initial preparation stage (i.e. manual excavation of communal ponds). The training and basic materials for excavation work of seasonal marshes were provided by MFA, JICA and Embassy of Japan in Guinea. Key features of the project are as follows; 1) utilisation of existing natural systems and practices, such as seasonal marshes as aquaculture fields, naturally entrapped wild fish fingerlings as seed, and cattle manure as fertiliser, 2) choice of communal ponds, instead of privately-owned ponds, 3) establishment of a management committee which collects revenue from fish sales and pond access tickets and utilises it for prevention of poaching, and 4) high compatibility with the existing life pattern of villagers (i.e. no special activity is required during the peak of annual crop production season).

The results of the pilot projects in 24 communal ponds in 2009 are as follows; 1) an average fish harvest of 542 kg per site, 2) an average density of 4,838 kg/ha which is high due to the fish concentration effect, 3) a total fish harvest increase from 3,532kg to 13,009 kg or 3.7 times, due to a combined effect of deepening and/or enlarging seasonal marshes, use of fertilisers and systematic pond surveillance, 4) *Clarias anguillaris*, *Oreochromis niloticus* and *Heterotis niloticus*, were the dominant fish species, 5) site selection and fish poaching prevention were key success factors, 6) additional outputs, such as creating aquaculture funds, reinforcing community solidarity, and reviving traditional marsh harvest festivals, and 7) organisational capacity improvement of villagers who gained knowledge and skills through trainings and trials about the natural mechanisms of extensive aquaculture, selection of suitable sites and management of communal ponds.

The features of the method and results of the community-based extensive aquaculture can be concluded as follows; 1) technically simple and cost-effective production with small initial inputs and advantage of the primary productivities of flood plains, 2) additional source

of sought-after animal protein production for villagers in rural areas, and 3) environment-friendly and sustainable production approach indicated by the fact that some villagers are constructing new communal ponds without any external assistance and willing to transfer the production method to nearby villages. The method is expected to contribute to rural development and food security of Guinea and to be applied in other flood plains in West African countries including Burkina Faso, Niger, Mali and Benin. Please see more details at: <http://www.jica.go.jp/project/guinea/061400002/03>

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Beel fishery development of West Bengal – its constraints and effective management

A.K. PANIGRAHI, C. DUTTA

*Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal India.
Email: panigrahi.ashis@gmail.com.*

India is blessed with huge inland water resources in terms of rivers, estuaries, lagoons, reservoirs, flood plain wetlands etc. Fresh water wetlands, flood plain lakes in the form of a beel, mauns, pats, tals, ox –bow lakes and similar other kinds of vast water bodies commonly found in the states of West Bengal, Assam, North Bihar, Tripura and North Eastern India constitute one of the cheap and remunerative source of fisheries. West Bengal is one of the leading states in this respect. The state has enormous aquatic resources mainly 2,760,000 ha of fresh water tanks and ponds, 410,000 ha of beels, baors and ox-bow lakes, 2,520,000 ha of river and canal systems.

The rich nutrients load and availability of fish food organisms make these water bodies ideal for culture based fisheries leading to higher growth of stocked fish species.

Though the beel fisheries contribute a major resource area, its contribution to the fish production in terms of potential area is very much discouraging. There has been inadequate attention to the maintenance of water bodies like tanks, pond, beels, baors resulting thereby reduction in the capacity of stocking due to growth of water hyacinth and weeds. Most of the farmers in West Bengal are traditionally culturing fishes in these water bodies.

With the sustained efforts, productivity in the beels can be raised from 150-200 kg/ha/year to 1200-1300 kg/ha/year. The marginal areas of the beels can be utilised for construction of ponds or pens of suitable sizes for raising the required fingerlings for stocking the beels.

Mangrove ecosystem and the related community livelihoods

R.H. BOSMA¹, S. YUMNONGSONG², V. DULYAPURK², A.S. SIDIK³, P.T.A. DAO⁴, L.X. TUAN⁴, P.A.M. VAN ZWIETEN¹, S.W. BUNTING⁵

1. Aquaculture and Fisheries, Wageningen University, Netherlands; 2. Faculty of Fisheries, Kasetsart University, Thailand; 3. Fisheries and Marine Science Faculty, Mulawarman University; 4. Mangrove Ecosystem Research Center, Hanoi, Vietnam; 5. University of Essex, United Kingdom. Email: roel.bosma@xs4all.nl.

Introduction

The mangrove ecosystem fulfils important functions but despite policy recommendations the area covered continues to decrease globally. The goal of the EU funded MANGROVE project (FP6-003697) is to identify methods for participatory management. Initially a detailed situation analysis, involving participatory community appraisals, stakeholder and institutional analysis, a study of the market networks for goods derived from mangroves and an assessment of existing datasets was undertaken in Mahakam delta Indonesia (MDI), Red River Delta Vietnam (RRDV) and Nakhon Si Thammarat mangrove, Thailand (NSTT). We explored the livelihood strategies of households dependent on goods and services derived from mangroves through a survey and logbooks. Existing policy and legislation relating to mangrove was characterised through a detailed institutional analysis involving local, national & international organisations. Stakeholders assessed the changing status of mangroves and values associate with them and identified indicators for participatory monitoring.

State of the system

While in Thailand and Vietnam mangrove replanting began over 30 years ago, at the same time in MDI massive conversion started. The inconsistencies between central and local land management policy in MDI permitted this to happen. Furthermore, in most MDI locations ponds are managed by caretakers, with the land title holders being absent. This arrangement also explains the low production level of ponds in MDI where caretakers' livelihoods are mainly based on collecting crabs and other resources. Recently replanting of non-productive ponds started; silvo-aquaculture systems are piloted, but concerns over the legality of land holdings may constrain development of participatory action plans.

In the RRDV collecting and culturing clams on mudflats and other mangrove related activities provides complementary income to many. The mangroves are mainly replanted and form, together with the mudflats, a safe heaven for migratory birds. In the highly dynamic situation one concern is whether the action plan developed by the pilot villages will be seen as representative of all stakeholder positions and thus merit support at the commune level.

In NSTT, people's livelihood options decreased after the government enforced the 1989 ban on mangrove cutting. Throughout the year the income for fishermen is stable but is only half the average income of small-scale aquaculture based livelihoods, which fluctuates over the year. Men, especially, derive a large part of their livelihood from the mangrove based ecosystems. However, the interactive participatory approach used and involvement of local, regional and national stakeholders resulted in broadly supported local action plans to reconcile multiple demands on mangroves.

Prospects

Participatory approaches based on the interactive involvement of stakeholders can produce well defined action plans with clear goals and appropriate indicators for monitoring implementation. However, complex relations between owners and caretakers as well as residents and state administration including inconsistencies between 'de jure' and 'de facto' legal situations, may constrain or prevent implementation of more equitable or sustainable management strategies.

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Aquaculture research challenges in the ECOWAS sub-region: Nigeria as a case study

A. RAJI, C.T. MADU

National Institute For Freshwater Fisheries Research, P. M. B. 6006, New Bussa, Nigeria, W. Africa. Email: niffish@yahoo.com.

ECOWAS (Economic Community of West African States) is a sub-regional group of fifteen West African countries with a mission to promote economic integrity for the self-sufficiency of member nations. Nigeria is the headquarters of ECOWAS and the leading country in aquaculture research and production with an annual fish production of 85,887 metric tonnes (in 2007) more than 85 per cent of the total production in the West African sub-region.

This paper discusses the status of aquaculture research in Nigeria which is presently within the mandates of two national research institutes and 34 universities that offer courses in aquaculture and related disciplines. One of the institutes, i.e. – the National Institute for Freshwater Fisheries Research, in New Bussa, Niger State, has recently been designated by the World Bank as a national centre of specialisation in aquaculture for the ECOWAS sub-region. Aquaculture research opportunities in Nigeria which are considered to be enormous are also discussed to include: the huge coastal and inland water mass and flood plains (over 16 million ha) available for aquaculture, large number of species of finfish and shell-fish with great potentials for aquaculture, relatively high number of research scientists and technologists in research institutes and universities, improved ICT for information

sharing, dissemination and collaboration and the friendly environment in Nigeria for year-round aquaculture research and development.

The major constraints are, however, pointed out and discussed. Aquaculture is relatively newer (less than 50 year old) than other agricultural sectors (crops and livestock) and is yet to gain adequate recognition and support from policy makers. Research is concentrated on two major groups of fish (catfishes and tilapias) leaving behind other commercially important and cherished species such as *Lates niloticus*, *Heterotis niloticus*, *Gymnarcus niloticus*, marine and brackish water species and shell fishes. Research is yet to come up with adequate cost efficient nutritionally balanced feeds for the cultured species. Also, the poor utilisation of research results by policy makers and practicing/potential fish farmers due to the weakness of research output extension linkages were discussed.

To be able to maintain the lead in aquaculture research in the ECOWAS sub-region some measures are suggested as the way forward. The government and policy makers should provide adequate funds for aquaculture research infrastructure, human capacity development and research project execution. Communities and private sector should be encouraged to participate in the development and funding of aquaculture research especially in such critical areas as fish feeds, fish seeds and the culture of new but popular choice fishes and shell-fishes. National, international and regional information exchange and networking centres should be established for dissemination of research results in Nigeria and the ECOWAS sub-region.

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An overview of shrimp culture systems and sustainability issues faced by shrimp producers in Thailand

ARLENE NIETES SATAPORNVANIT^{1,2}, KRIENKRAI SATAPORNVANIT², FRANCIS MURRAY¹, DAVID LITTLE¹

1. *Institute of Aquaculture, University of Stirling, Scotland FK9 4LA U.K.*; 2. *Faculty of Fisheries, Kasetsart University, Bangkok 10900 Thailand.*

The Sustaining Ethical Aquaculture Trade (SEAT) Project is exploring the sustainability of trade of major aquaculture species from Asia to Europe, considering the whole value chain. Results of the initial research (scoping phase) in Thailand through field visits and secondary data collection revealed that Thailand's shrimp culture industry continues to strengthen efforts to produce high quality shrimp sustainably as it leads in production and export. *Litopenaeus vannamei* (white leg shrimp) has replaced *Penaeus monodon* as the species of choice since the early 2000s due to its fast growth, ease in culture, resistance to diseases and higher yields. It now comprises more than 97% of the total shrimp produced. In 2008-2009, Thailand produced more than 540,000 MT of shrimp, and in 2009, it exported more than 390,000 MT worth 93.4 billion Baht, mainly to USA, Japan, Canada, Europe, ASEAN, Hong Kong and Australia.

Based on district level data collected, selected sites in the main shrimp producing areas in the eastern and southern regions were visited, including an organic shrimp farm. Information was obtained through various means such as key informant interviews, direct observation, local data and participation in various stakeholder meetings.

Major similarities and differences in culture systems and management exist among different farm scales and geographical locations. Closed systems are used by all farms, although heterogeneous with respect to specific biosecurity measures and scales, which are resource dependent. Both semi-intensive (9%) and intensive (91%) systems are widely practiced, with production mainly geared for export. The use of antibiotics and chemicals has dropped significantly since the early 2000s and farms visited have ceased using them, which is the current trend along with increased probiotics use. Organic shrimp farming is also being promoted. Shrimp culture area expansion appears limited by environmental laws, land use competition with other economic activities, or conversion to less risky investments.

Concerns for sustainability in production and trade continue however, most importantly, for local stakeholders being the selling price of shrimp. Producers need a higher price whereas buyers offer cheaper prices. Among other major issues include high cost of feed, energy use, disease outbreak, quality of incoming water and inadequate information on importing country requirements. The cost for private certification, increasingly required by importers, has become an issue. Some small scale producers who do not have enough resources to operate and to comply with certification opt to lease out their ponds to others or stop altogether.

Support from state institutions has been crucial in regulation and quality control. All farms area registered and following Good Aquaculture Practices guidelines, while producers' groups provide members a voice in negotiations with other power brokers such as feed companies, processing plants, exporters and private certifiers, and opportunities for sharing information and learning together. Producers hope that their efforts in producing quality safe shrimp sustainably will be recognised by processors, importers and consumers. An evidence-based system is therefore necessary.

Sustainability issues emerging during the scoping phase of the SEAT project will be addressed through action research with interested stakeholders, commencing in late 2010.

Between delicatessen and trashfish? Lessons learnt from marketing trials with the Philippine milkfish (*Chanos chanos*)

U. SCHOLZ¹, R. MUEDA², T. DACLES³, M. KELLER⁴

1. German Technical Cooperation-GTZ, Environment and Rural Development Programme, Manila, Philippines; 2. University of the Philippines in the Visayas, Miagao, Iloilo, Philippines; 3. German Technical Cooperation-GTZ, Environment and Rural Development Programme, Bacolod, Philippines; 4. Bundesverband Fisch, Hamburg, Germany.
Email: uwe.scholz@gtz.de.

The milkfish, *Chanos Chanos* is considered as the economically most important aquaculture species in the Philippines. It receives a high attention in the diet of the Filipino people and is in general regarded by many as the “national fish”. The total production in 2005 reached to 289,151 MT (BFAR, 2005) and with approximately 99% being absorbed by the domestic market. The fish is traditionally cultivated in coastal ponds. However, new production methods in fish cages have created an uneven production and marketing patterns throughout the country with a surplus production in the Western Visayas and Northern Luzon regions. This surplus poses an opportunity in processing and marketing in particular for export to the EU.

The poster presents the results of marketing trials in Germany, including product development examples plus the different preferences of European and Asian processing industries, which, in the case of Germany, turned out to be skinless and boneless fillets only. In general, there are a lot of challenges in penetrating the European market, however, there is a certain potential to occupy a niche market for delicatessen products with an additional value if organic certification is applied. The poster will further outline product attributes of milkfish and its characteristics.

The poster will also present the NISARD-Organic Certificate which was developed in the Philippines in cooperation with the renowned German Company Naturland e.V. and is the first one applied in the country.

Community-based management of Vishnupuri reservoir for food security and rural livelihood

D.N. THAKUR, B.R. CHAVAN

College of Fisheries, Dr. B. S. K. Agricultural University, Ratnagiri (MS), India.

Email: dhanrajsingh_thakur@hotmail.com.

In India, Maharashtra State has total water resources of 311,000 ha of tanks, ponds, lakes and reservoir which have recently gained significance as a prospective aquatic resource. In the present study, the existing management systems of Vishnupuri reservoir are reviewed. There are eight fisher co-operative societies and livelihoods are dependent on Vishnupuri reservoir. Participatory Rural Appraisal (PRA) revealed that lack of adoption of new technology and proper management of aquatic resources as a major constraint reflected by the weighted mean index. Resource-poor landless fisherfolk felt the need for adoption of new technologies for aquatic stock enhancement. It was found that the fishers are keen to introduce new technologies for utilisation of underutilised water resources. Therefore, there is urgent need to utilise these resource to a complete potential requires consideration of crab cage culture, edible fish cage culture, aquarium fish cage culture and *Spirulina* culture by resource-poor landless fisher communities as a compliment to existing stock enhancement programs. Evidently, the harvested aquatic production has become a problem for maintaining of its quality, and therefore, to effectively address the problem suitable culture techniques, harvesting, preservations and marketing must be introduced. There is need to train rural fisher youth with respect to dissemination of modern aquatic resources management techniques and efficient marketing.

Keywords: Vishnupuri reservoir, crab cage culture, aquarium fish cage culture, spirulina culture

The modern condition, problems and opportunities for development of aquaculture in Azerbaijan

T. ZARBALIYEVA, M. AXUNDOV, R. HAJIYEV, A. QASIMOV, Z. SALMANOV

Ministry of Ecology and Natural Resources of Republic of Azerbaijan, Department for Reproduction and Protection of Aquatic Bioresources, Azerbaijan Fisheries Research Institute.

Aquaculture in Azerbaijan functions in two directions: pasturable aquaculture and fresh-water aquaculture. Pasturable aquaculture has a traditional character, since 1950 it serves for updating commercial resources of sturgeons (Acipenseridae), The Kura salmon (*Salmo*

trutta caspius), carp (Cyprinidae) by the state piscicultural enterprises, and also preservation of a genetic variety of the Kura fish herds in natural reservoirs. Annually four state sturgeon piscicultural enterprises grow up and release in the Caspian Sea about 13.7 million pieces of young fish, and since 2002, 110 million young fish were released. Replenishment of resources of the Kura salmon is carried out by three piscicultural enterprises. The number of grown young fish has been increased to 50 thousand pieces (in 2002) up to 118 thousand (in 2009) smolt, and part of it is released in Pre-Kura area, other part is continued to be grown up in corfs in sea conditions for bigger weight, and then released in the sea. Piscicultural enterprises on growing of carp fishes are specialised on annual production of 410-450 million pcs. of young kutum fishes, voblas (roach), bream, shemaya, a pike perch (zander).

The development of fresh-water aqua culture, production of commodity fish has been started in Azerbaijan since 1960. Up to 2 thousand tons of fish: carp, were grown up in state piscicultural enterprises in a year. In the last 10 years, after transfer of fresh-water aqua culture to private sector, creation of small farms for cultivation of fish is observed in the republic. By present time the total area of aqua culture facilities in the republic has reached nearby 10 thousand hectares, however their productivity is low. Cultivation of a commodity fish in corfs of Mingechaur water reservoir has been started; preparation works on cultivation of commodity sturgeon are underway. In mountainous areas commodity cultivation of a trout (*Salmo trutta faria*) is carried out, increase of volumes of production is noted.

Development of fresh-water aqua culture is constrained by absence of the national legislation on aquaculture. In addition, small farmers are faced with several problems including financial and technical.

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Strengthening adaptive capacities to the impacts of climate change in small-scale aquaculture in South and Southeast Asia

NIGEL W. ABERY, SENA S. DE SILVA

Network of Aquaculture Centres in Asia-Pacific. PO Box 1040 Kasetsart Post Office, Bangkok 10903 Thailand. Email: nigel.abery@enaca.org.

As the world population increases and demand for seafood follows, the bulk of production is expected to come from aquaculture. However, it will not be without challenge. The bulk of current and future world aquaculture production is expected to come from Asia. The backbone of the Asian aquaculture production is small scale producers who are believed to have poor adaptive capacity. Areas most at risk from climate change are believed to be island, coastal and deltaic areas which are also some of the most productive aquaculture areas.

The Network of Aquaculture Centres in Asia-Pacific (NACA) is coordinating a project to strengthen the adaptive capacities of aquaculture to climate change. The project branded “Aquaclimate” aims to strengthen the adaptive capacities of selected rural farming communities, some of the most potentially vulnerable, to the impacts of climate change. The project focuses on small-scale aquaculture and related sectors that are comprised largely of poor people who depend on aquatic resources for their livelihoods. The project is working on key sectors in four countries: striped catfish and black tiger shrimp in Vietnam; milkfish in the Philippines, Black tiger shrimp in India and culture based reservoir fisheries (mixed species) in Sri Lanka.

Key project activities thus far include focus group discussions with aqua-farmers and stakeholder workshops for case studies in Vietnam, India and the Philippines identifying aqua-farmer and stakeholder perceptions of recent climate changes, their impacts on their farming system in terms of production and economics, implemented and suggested adaptation measures.

It is evident that aqua-farmers in the case study areas already perceive that there have been recent changes in the climate that are having impacts on their farming systems and livelihoods and adaptation actions at different levels (farmer implemented, research and policy and institutional) to help small scale aqua-farmers to adapt to climate change have been discussed by key stakeholders.

Some of the key climate changes impacting on aquaculture perceived aqua-farmers include:

- Saltwater intrusion impacting on striped catfish (a stenohaline freshwater fish) production in the Mekong delta. Irregular weather such as high temperatures or heavy rainfall causing water quality problems for shrimp farmers on the lower Mekong delta.
- Tidal irregularities and increasing higher tidal surges (overtopping pond banks) impacting on coastal pond milkfish farming in the Philippines.
- Extreme climatic events, flooding, drought and high temperatures impacting tiger shrimp farming in Andhra Pradesh, India.
- The project is also identifying vulnerability indicators and benchmarking aqua-farmer vulnerability to climate change so that responses can be more targeted.
- The project will also focus climate change mitigation capacity of aquaculture and on future predicted climate changes and how these may impact on or provide opportunities for aquaculture in the future.

Catfish farming production model (Mekong Delta, Vietnam) and climate change impact linkages and derivatives

VARUNTHAT DULYAPURK¹, METHEE KAEWNERN¹, SIRISUDA JUMNONGSONG¹, NIGEL ABERY², SENA S. DE SILVA²

1. Department of Fishery Management, Faculty of Fisheries, Kasetsart University, Bangkok, Thailand; 2. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand.

The project on “Strengthening Adaptive Capacities to the Impacts of Climate Change in Resource-poor Small-scale Aquaculture and Aquatic Resources-dependent Sector in the South and South-east Asian Region” also known as “Aquaclimate” aims to strengthen the adaptive capacities of rural farming communities to the impacts of climate change including Vietnam catfish farming. Based on 190 questionnaires collected within the major catfish producing provinces, Soc Trang (15), Tra Vinh (15), Dong Thap (53), Can Tho (82) and Vinh Long (25), respectively, the project is developing a catfish production model to identify the major inputs used by these small-scale catfish farms and further investigate the link between these major inputs and catfish farmer perceptions and experiences on climate change impacts (e.g., floods, irregular weather, typhoon/heavy rain/storm/ temperature fluctuation, salinity and others). Multiple regression technique was applied to quantify any statistically significant results. Based on general catfish production and catfish revenue (million VND per crop) has been used as the dependent variables which can theoretically be explained by three major input groups; group of socioeconomic variables, group of catfish production variables, and group of climate change perceptions and experiences, respectively. The pond area (ha), total commercial feed (million VND per crop), total temporary and permanent labor cost (million VND per crop), total seed cost (million VND) and quantity (1,000 fry), water depth (m) and personal experience on the extreme weather in the past seven years, respectively, have been identified as positively related major inputs for overall small-scale catfish production whilst negatively related major inputs are total sediment removal cost (million VND per crop), pond age (year) and pond depth (m), respectively. The linkages between these statistically significant variables and catfish farmer perceptions and experiences on climate change impacts have been identified. Salinity problems, among others, have been recognised as a major climate change impact for catfish farming in the Mekong Delta.

Perceived impacts and adaption to climate changes of small scale shrimp farming in Ca Mau Province

NGO VAN HAI¹, NGUYEN VAN HAO¹, NIGEL W. ABERY² AND SENA S. DE SILVA²

1. Faculty Research Institute for Aquaculture No.2, 116 Nguyen Dinh Chieu Street, District 1, Ho Chi Minh City, Vietnam; 2. The Network of Aquaculture Centres in Asia-Pacific, PO Box 1040 Kasetsart Post Office, Bangkok 10903. Thailand. Email: ngovanhai@yahoo.com.

One hundred improved extensive shrimp farmers in Dam Doi and Cai Nuoc districts, Ca Mau Province were interviewed about their perception on climate change, the impacts on their farming system and climate change adaptation measures, and farmers' capacity to mitigate climate change. The results showed that most black tiger shrimp (*Penaeus monodon*) farmers are poorly educated with 47% finishing primary school. Tiger shrimp farming in Ca Mau operates year round and is often operated as a poly culture with mud crab (*Scylla paramamosain*). The mean yield of shrimp was 128 kg-1ha⁻¹year⁻¹, while the mean yield from mud crab was 37.8 kg⁻¹ ha⁻¹ year⁻¹.

The pond structures and practices were not different between the two districts. Ponds were prepared once a year. The sediment was used to consolidate dykes to deal with increasing levels of tidal flooding perceived to be due to sea level rise or other climate change events. No correlation between the numbers of year experience and the yield, between the areas and the yield, between the education level and the yield were found.

The farmers' perception on climate change were still vague, but 86, 70, 69, 67% of farmers have claimed that sea level rise, high temperature, irregular weather and too much rain, respectively, were the most important factors in small-scale shrimp farming. Farmers suggested some ideas to adapt to climate change, in which they have heightened the roles of stakeholders, who have to collaborate and coordinate the development of action plans and appropriate strategies for sustainable shrimp farming suitable for potential climate and weather scenarios. The agreement on water and sediment treatment and discharge among farms in certain areas could be established and regulated by the government for sustainable development.

Potential adaptation measures such the introduction of new species (both native and exotic species) appropriate to the environment and ecology need to be considered. Farmers suggested that i) aquaculture extension activities should focus on disseminating culture techniques appropriate for new climatic conditions; ii) weather broadcast on television should be on time, with more frequency and accuracy; iii) agricultural banks or other funding sources should have long term loans for improving shrimp farming; iv) reforestation of mangrove was priority in the coastal areas.

Although climate change events have affected small-scale shrimp farming with losses typically between 10-30% and up to 100% of income in some cases, the farmers do believe that shrimp farming still remains a viable industry in the long term.

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Potential climate change impacts on social vulnerability and adaptive capacity of striped catfish (*Pangasianodon hypophthalmus*) farming community, Mekong Delta, Vietnam

TRUONG HOANG MINH¹, NIGEL W. ABERY², NGUYEN THANH PHUONG¹, UDAYA SEKSHAR NAGOTHU³, SENA S. DE SILVA²

1. Faculty of Fisheries, Can Tho University, Can Tho, Vietnam; 2. The Network of Aquaculture Centres in Asia-Pacific, PO Box 1040 Kasetsart Post Office, Bangkok 10903. Thailand; 3. Bioforsk, Norway. Email: thminh@ctu.edu.vn.

The striped catfish farming industry in the Mekong delta is a billion dollar industry that supports hundreds of thousands of livelihoods and provides affordable seafood to numerous countries worldwide. The bulk of the production is from small-scale producers, who though may produce a thousand tonnes per crop/ha, operate at very high densities and on low profit margin per tonne.

The striped catfish farming industry is not without issues, in addition to market and price variability, market barriers, food safety and environmental sustainability concerns the industry has recently been impacted by climate changes, and will continue to be impacted.

Farmer and stakeholder perception about climate change and production and socio-economic information was obtained from focus group discussions, a stakeholder workshop and an expansive (190 respondents) farmer survey that was undertaken in the Mekong delta from June to December 2009.

Key recent climate changes identified included: irregular weather patterns (higher temperatures), prolonged hot season, early rains, suddenly heavy rain, floods, higher river water level, water quality changes, saline water intrusion, sea level rise and frequent typhoons. These changes have caused major impacts including increasing disease occurrence, lower growth and survival rates, lower production, bad water quality, poorer flesh quality, destruction of the irrigation system, loss of production area, and higher production costs due to increased expenditures on chemicals and drugs, repairing and upgrading dikes, etc.

Farmers' and stakeholder adaptation suggestions include changes to management practices, producing and using good quality seed, developing new/improved culture systems/species, improved infrastructure, livelihood diversification, training and awareness

workshops, financial support, and zoning and timing for culture area. Furthermore, there seems to be willingness among stakeholders to cooperate in their efforts to address future threats from climate change.

A social vulnerability indicator was developed from responses to a farmer survey and is composed of social factors that are highly variable across the population of catfish farmers and is associated with catfish farmers' perceived degree of difficulty in overcoming losses due to the damage from the extreme weather events include: size of farm; age; number of farms; percentage of income from catfish farming; education level; trainings attended; experience in fish farming.

P-101

Culture performance of pacific cupped oyster (*Crassostrea gigas*) in the sea affected by oceanographic features combined with short and large scale climate events

DARIEN D. MIZUTA¹, CHRISTINE E. FISCHER², NELSON SILVEIRA-JÚNIOR², DANIEL LEMOS¹

1. Marine Aquaculture Laboratory, Oceanographic Institute, University of São Paulo, São Paulo, Brazil; 2. Atlântico Sul Marine Farm, Florianópolis, Brazil. Email: dellemos@usp.br.

Aquaculture of filter-feeding bivalve molluscs involves the fruitful conversion of marine particulate organic matter into premium protein of high nutritive value. It may be environmentally and socially positive in many coastal regions with minor potential impacts due to waste output. Culture performance of bivalves is largely dependent on hydrological conditions and directly affected by e.g. temperature and chlorophyll levels. Accordingly, these parameters may be dependent on seasonality but also on oceanographic features combined with climate events. Yields of juvenile Pacific cupped oyster (*C. gigas*) reared at commercial farm in suspended structures (long-lines) in a sheltered bay in Southern Brazil (Santa Catarina State, 27S 43'; 48W 30') were evaluated in relation to local environmental conditions: sea surface temperature, chlorophyll a concentration, and associate effects of cold fronts events and El Niño and La Niña periods. Outputs from four consecutive crops were analysed (2005/06, 2006/07, 2007/08, 2008/09) in terms of survival and development time during the main phases of the culture cycle: seed to juvenile, juvenile to adult, adult to marketable. Significant differences among crops performance were verified that could be mostly related to environmental effects since culture management and genetics standards were comparable. Time series of temperature and chlorophyll a from crop intervals displayed significant seasonal and inter-annual variation. Performance in initial culture stages (seed to juvenile) was critical for crop final yield. Temperature was the main factor affecting survival in these stages with a significant negative correlation, whereas chlorophyll may mitigate the negative effects from elevated temperatures if available at high concentrations. On the other hand, oyster development was significantly and positively affected by chlorophyll a levels. Chlorophyll a values could be increased by upwelled cool

nutrient-rich South Atlantic Central Water (SACW, related to predominant Northern winds) depending on occurrence of Southern winds (cold fronts) to assist seawater penetration into the sheltered bay. Less saline nutrient-rich northward drifted waters from La Plata River discharge may also result in chlorophyll enhancement in the culture area. The El Niño period (May 2006 to January 2007) was associated with lower chlorophyll a levels in the culture zone that may be related to both a decreased number of cold fronts as well as predominance of Northern winds that retain northward spreading of La Plata discharge waters. In contrast, the La Niña period (August 2007 to August 2008) coincided with higher chlorophyll a values in the bay by both SACW and La Plata discharge water penetration facilitated by increased occurrence of Southern winds and cold fronts. The recognition of the potentially changing climate and effects upon the environment will be an important step in planning future development of bivalve aquaculture.

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Strengthening adaptive capacities to the impacts of climate change in small-scale Tra catfish (*Pangasianodon hypophthalmus*) farms in Dong Thap and Vinh Long provinces, Mekong Delta, Vietnam

PHAM BA VU TUNG¹, NGUYEN VAN HAO¹, TRAN QUOC CHUONG¹, NGUYEN THI HOAI AN¹, PHAN THANH LAM¹, NIGEL W. ABERY² AND SENA S. DE SILVA²

1. Research Institute for Aquaculture No.2, 116 Nguyen Dinh Chieu Street, District 1, Ho Chi Minh City, Vietnam; 2. The Network of Aquaculture Centres in Asia-Pacific, PO Box 1040 Kasetsart Post Office, Bangkok 10903. Thailand. Email: vutungria2@yahoo.com.

Adaptation to climate change involves changes in catfish farming management practices in response to changes in climate conditions. It often involves a combination of various individual responses at the farm-level. This study examines farmer adaptation strategies to climate change based on a random cross-section of 88 small-scale Tra catfish farmers in Dong Thap and Vinh Long provinces.

The result describes farmer's perceptions on climate change in temperature - very hot and very cold, floods, precipitation - early rain heavy rain, season timing changes, water pollution, river/canal level rise and wind changes. Impacts from these changes were considered to be increases in fish disease occurrences, poor water quality, higher operation cost and reduced production. There are various farm-level adaptation measures and barriers to adaptation at the farm household level. Some key potential adaptation strategies include: access to credit, development of improved management practices and technology, extension and awareness of climate change issues and solutions for farmers. Research and development on appropriate technologies is needed to help farmers adapt to changes in climatic conditions.

Keywords: Stripped catfish, Tra catfish, small scale, Vietnam, climate change, adaptation, Dong Thap and Vinh Long province

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Effects of cadmium chloride (CdCl₂.H₂O) accumulation, 96-h LC₅₀ values and behavioural changes in *Chanos chanos*

N. AMROLAHI BIUKI¹, A. SAVARI¹, MS MORTAZAVI², H. ZOLGHARNEIN¹, S. ASOUDEH³

1. Department of Marine Biology, Faculty of Marine Science, Marine Science and Technology University, Khoramshahr, Iran; 2. Persian Gulf and Oman Sea Marine Biology and Ecology Research Center, Bandarabbas, Iran; 3. Department of Marine Biology, Faculty of Science, Hormozgan University, Bandarabbas, Iran. Email: bionab1@gmail.com.

The contamination of water by heavy metal is a worldwide environmental problem. Concentrations of heavy metals have been increasing in aquatic environments as a result of human activities. Various metals have the capability to induce harmful effects on living organisms. In this study the 96-h LC₅₀ values of cadmium chloride (CdCl₂.H₂O) and its effects on behavioural changes on milkfish (*Chanos chanos*) were investigated. Young juvenile milkfish (W: 64±1.2 g, SL: 16.7±0.4 cm) were exposed to Cd at concentrations of 0.1, 1.0, 10.0, 30.0, 60.0, 90.0, and 120.0 mg/l. The experiments were performed in triplicate, and behavioural changes in the all specimens were determined for each concentration. Water quality parameters of the test seawater were: hardness, 193.4 mg/l as CaCO₃; pH, 7.6 to 8.1; dissolved oxygen concentration, 6.7 to 7.8 mg/l and salinity: 38.3 psu. The data obtained were statistically evaluated by the use of EPA computer program based on Finney's Probit Analysis Method. The 96-h LC₅₀ value was found to be 62.8 mg/l in a static bioassay test system. The behavioural changes observed in fish were, swimming disorders such as vertical and downward manner, abnormal swimming, suspending motionless on water surface and swimming around its own axis. In high concentration the fish were observed to have breathing difficulties and tried to breathe air from the surface and their motility slowed down and increased mucus secretion.

Head dorsal, eyes and all fins were bloody. There were no behavioural changes and deaths observed in the control group throughout the experiment. The results obtained in this study showed heavy metal affected on organism and clearly reveal the fact that it is necessary to control the use of all heavy metals such as cadmium.

Keywords: cadmium, behaviour, *Chanos chanos*, heavy metal, LC₅₀

Monitoring marine aquaculture wastes in Igoumenitsa Bay (NW Greece)

P. BEZA^{1,2}, A. CHATZOPOULOS, V. MOUSSIS², A. BOUGIOKLIS², T. MAVRAGANIS¹, C. NATHANAILIDES¹

1. Department of Aquaculture and Fisheries, Technological Education Institute of Epirus, Igoumenitsa, Greece; 2. Department of Chemistry, University of Ioannina, Ioannina, Greece.
Email: cosmasfax@yahoo.com.

Eutrophication in coastal zones is related to nutrient over-enrichment (nitrogen, phosphorus and silica). The phytoplankton production depends on supplies of nitrate-N and phosphate-P. An increase in this nutrient usually results in eutrophic conditions with seasonal algal blooms. Fish farming often results in a generation of a nutrient load which contain uneaten feed, faeces, and both organic and inorganic elements, such as nitrogen molecules and phosphorus. The purpose of this work was to monitor nutrient enrichment around a fish farm site in Igoumenitsa Bay (NW Greece). The bay has an opening to the sea facing the Corfu strait, and is protected by high waves by a narrow landline. The fish farms in the monitored site exhibit an annual production over 450 tonnes. The main species cultivated in the floating cages are sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus auratus*). The dispersion pattern of fish faeces was estimated according to current velocities and directions. The waters surrounding the fish farms exhibited profound increased mean annual content of phosphorus, which peaked during the summer months. This increase in phosphorus was also reflected in high primary productivity as indicated by increased chl-a content at the sites of the fish farms. The model of dispersion of wastes generated by the fish farms indicates that the major path of dispersion is towards the coast and over a range of more than 120 meters. The location of the fish farms and the prevailing direction and velocity of water currents may result in the diffusion of nutrient from point sources such as the fish farms towards deepest part of the bay (south). This information can be useful for the management of aquaculture development in the bay, it would however be necessary to obtain more data and to study the patterns of benthic community changes in different location bellow and further from the fish farms. Fish farms can generate nutrient waste (uneaten food and metabolic waste). Changes in the chl-a content can be an indicator of changes in plankton primary productivity. The levels of chl-a observed here indicate a medium status of eutrophication in the bay but during summer, when currents are minimal, PO₄ and chl-a content in the fish farms samples indicated a high level of organic load. Currents may wash and dilute a point source of organic enrichment by the fish farms, but low current velocity during summer can reduce the dispersion of organic wastes generated by the fish farms at a time that feeding regime is increased due to favourable temperature conditions. This combination of physicochemical conditions and aquaculture management may explain the high peaks of chl-a content in the location of fish farms during the summer. This information can be useful for the management of aquaculture development in the bay, it would however be necessary to obtain more data as well to study the benthic community bellow and further from the fish farms.

Life cycle assessment for aquaculture: stakeholder interests and roles

ROEL BOSMA¹, JOSÉ POTTING², JOHAN VERRETH¹

1. Aquaculture and Fisheries; 2. Environmental Systems Analysis, Wageningen University, Postbus 338, 6700 AH, Netherlands. Email: roel.bosma@xs4all.nl.

Introduction

Life cycle assessment (LCA) is an established method for environmental impact assessment of food products (Bartley et al., 2007; Peters, 2009). LCA is standardised method to assess the contribution of all cradle-to-grave processes in a production system to a broad range of environmental impact categories (ISO 14044, 2006). Pelletier et al., (2007) concluded that a number of impact categories are most relevant for aquaculture LCAs.

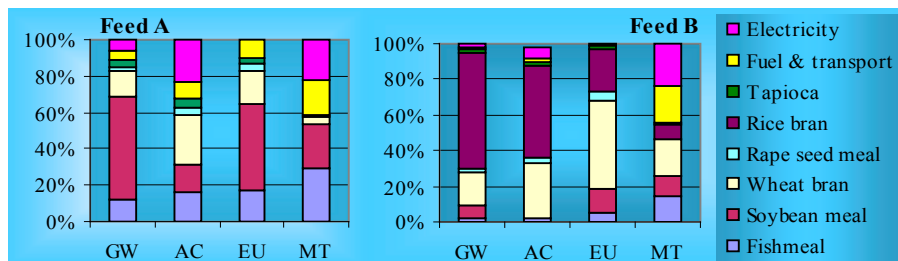
LCA advantages

Bosma et al. (2009) made a cradle-to-gate LCA of pangasius farming in the Mekong delta and confirmed that feed production dominates the environmental impact and feed composition influences the overall impact (See bar charts). LCAs of aquaculture show that feed typically causes 50 to 70% of direct and indirect environmental impact (e.g. Roque d'Orbcastel et al., 2009). Reducing feed conversion ratios is thus one of the first priorities. Based on LCAs, industry can manufacture low impact feeds, but trade-offs exist between economics and impact categories. Thus stakeholders have to rank preferential reduction options according to their priorities, and policies are needed to motivate farmers using low impact feed. The sector needs to improve its image. LCA may assist in optimising environmental performance of the sector as it enables a systematic assessment, enables transparent communication with consumers and politicians, and structures involvement of stakeholders. LCA forces to objectively assess the entire production chain and thus gives a fair comparison between sectors and systems.

Conclusions

Feed typically dominates the environmental impact of aquaculture products. Sector and society need to set priorities in mutual agreement. Mitigations of environmental impacts can be obtained by: (1) reducing feed conversion ratio's, (2) using low impact ingredients by feed industry based on LCA.

Bar charts of the environmental impacts of two different feeds and their ingredients for four impact categories



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An Investigation of mercury bioaccumulation in *Metapenaeus affinis* from Musa Creek (Northern part of the Persian Gulf)

ALI DADOLAHI-SOHRAB^{1*}, MAHNAZ JALILIAN², YADOLLAH NIKPOUR³

1. Dept. of Marine Environment, Faculty of Marine Natural Resources; 2. Dept. of Marine Biology, Faculty of Marine Science and Oceanography; 3. Dept. of Marine Chemistry, Faculty of Marine Science and Oceanography, Khorramshahr Marine Science and Technology University, 669, Khorramshahr, I. R. Iran.

The purpose of this study was to determine the level of total mercury in the hepatopancreas, exoskeleton and muscle of white shrimp *Metapenaeus affinis* collected from Musa Creeks region (Northern part of the Persian Gulf). The sampling of shrimp has been done using bottom trawl. Samples were collected during February 2009, from five stations (Jafari, Ahmadi, Qanam, Qazaleh and Doraq) of the region. Analyses were carried out by reducing mercury compounds after acid digestion, reduction with SnCl₂ and detection by cold vapour atomic absorption (Model Unicam 919). In this study, maximum concentration of

total mercury in all tissues of *M. affinis* was observed in Jafari station ($p < 0.05$), which probably the main reason could be related to wastewaters discharged from Bandar Imam petrochemical company which is located nearby. The highest concentration of mercury was detected in hepatopancreas among different tissues, because hepatopancreas is the main organ of regulating heavy metal in crustaceans and acts as the first site of metal accumulation and detoxification. Concentration of total mercury in different tissues of *M. affinis* decreased in the following order: Hepatopancreas > exoskeleton > muscle. In addition, concentration of total mercury in edible tissue of *M. affinis* compared with the standards values of WHO, FAO, UKMAFF and USFDA. The results showed in Jafari and Ahmadi stations, concentration of total mercury was higher than UKMAFF standard value and lower than others. In other stations, concentration of total mercury in muscle was lower than all standard values. In this study, One-way of ANOVA and regression analysis were used to study bioaccumulation of total mercury in different tissues of *M. affinis* shrimp and stations.

Keywords: Persian Gulf, Total Mercury, Shrimp, Metapenaeus affinis, Musa Creek.

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Ecosystem approach aquaculture management in Turkey

HAYRI DENİZ

*Ministry of Agriculture and Rural Affairs Aquaculture Department, Turkey.
Email: hayri.deniz@tarim.gov.tr & hayrideniz@hotmail.com.*

Although the world fisheries production in 2007 was 145 million tonnes, production coming from capture fisheries has been declining due to overfishing and pollution. Therefore, to meet the increasing demand for sea food products, aquaculture is the only alternative.

Aquaculture is the fastest growing food production sector in the world and has developed rapidly. Total production share from aquaculture increased from 8 % in 1984 to 37 % in 2007.

Aquaculture in Turkey started in the 1980s and by rapid development, it reached 152,186 tonnes in 2005. However, although positive developments have been recorded, the new Environmental Law enforced in 2006 resulted in the confinement to 166 sea farms and all this adverse developments have affected the sector in a negative way.

Owing to contribute to the solution of these problems, in 2008, FAO supported “Developing a Roadmap for Turkish Marine Aquaculture Site Selection and Zoning Using an Ecosystem Approach to Management”.

The results of the project study on environmental impact of aquaculture can be introduced and the work to be done for sustainable development not only in aquaculture but also other sectors have to be examined with defining carrying capacity, and an integrated management needed to be put in place.

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Development of Better Management Practices for catfish farming in the Mekong Delta, Vietnam

LAM T. PHAN¹, TAM M. BUI², THUY T.T. NGUYEN³, GEOFF J. GOOLEY⁴, BRETT A. INGRAM⁴, HAO V. NGUYEN¹, PHUONG T. NGUYEN², SENA S. DE SILVA³

1. Research Institute for Aquaculture No. 2; 2. College of Aquaculture and Fisheries, Can Tho University, Can Tho, Vietnam; 3. Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok 10903, Thailand; 4. Fisheries Victoria, Department of Primary Industries, Victoria, Melbourne, Australia.

Catfish farming in the Mekong Delta, Vietnam, has undergone rapid expansion over the last decade, with production peaking at > 1.3 million tonnes worth > US\$1 billion in export trade during 2008. The industry consists of both large, industrial-scale and large and small household-scale farmers utilising intensive but otherwise relatively simple pond production methods, including use of artificial feeding and frequent water exchange to achieve rapid growth over typical 6-7 month cropping cycles. More recently, farmers have come under considerable market-based pressure to accommodate reduced farm-gate prices and increasing demand for traceability and certification of food safety and environmental standards. Reduced profitability has seen total annual production decrease to less than 1 million tonnes over the last twelve months, with expectation that farmers need to reduce production costs, increase farm-gate price and enhance environmental management to ensure long-term sustainability. To this end, AusAid (CARD) has funded a project which commenced in 2008 designed to develop Better Management Practices (BMPs), which is science based, for the catfish farming sector in the Mekong Delta.

BMPs are a simple, cost-effective means by which farmers can be assisted to improve productivity and reliability of farming systems through adoption of standardised management practices, including management of feeding, water quality and exchange, fish health, seed quality, sludge removal and re-use and record keeping. Draft BMPs have been prepared by the project for both the grow-out stage and for the hatchery/nursery stage of the market chain following the first ever comprehensive baseline survey of industry practices. The project is being undertaken is a collaboration between Research Institute for Aquaculture No. 2, Can Tho University College of Fisheries and Aquaculture, Network of Aquaculture Centres in Asia-Pacific and Department of Primary Industries, Victoria, Australia, and is due for completion in 2010. The project is utilising a cluster-based approach to BMP adoption, and in partnership with leading farmers is presently undertaking farm-based trials to

demonstrate draft BMPs in four provinces of the Delta. Preliminary results indicate positive social, economic and environmental impacts at the farm level from adoption of BMPs. The role of clusters, in the form of farmer associations, is likely to be critical to the longer term industry-wide adoption and implementation of BMPs, with evaluation surveys showing that increased communication and sharing of knowledge between farmers is enhancing technical innovation and financial decision making and environmental performance of farmers. A national workshop is also proposed in late 2010 to present project findings and to facilitate consideration of the benefits of developing a BMP 'value chain' approach to industry development going forward.

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Nutrient discharge, retention and accumulation in pond aquaculture in Hungary

D. GÁL, É. KEREPÉCZKI, P. SZABÓ, F. PEKÁR

Research Institute for Fisheries, Aquaculture and Irrigation (HAKI), Anna-liget 8, H-5540 Szarvas, Hungary. Email: gald@haki.hu.

Pond culture is a traditional method of fish production in Hungary as well as in Central and Eastern Europe and is performed in large earthen ponds of one to several hundred ha. Common carp is the main species cultured, sometimes associated with Chinese carps, other cyprinids and piscivorous fish. In Hungary, more than 80% of the total fish production originates from ponds, and the fish yields in the extensive and semi-intensive fishponds varies between 500 and 2,000 kg ha⁻¹ year⁻¹. In pond aquaculture, only cereals and grains are applied as supplementary feed, typically contributing to 30-60% of fish mass gain. The effluents from fish farms are characterised by relatively large volumes; 60% of the total agricultural water use originates from the pond aquaculture in Hungary. The main pollutants of the aquaculture effluents are organic suspended solids, nitrogen and phosphorus compounds, which may result in eutrophication in the receiving water; but there are very few data available about nutrient discharge of pond aquaculture. The aim of this study was to survey the nutrient status of fishponds, and determine the nutrient discharge to receiving waters and evaluate the nitrogen (N), phosphorus (P) and organic matter (OM) budgets of fishponds.

The investigations were carried out on water quality and production parameters of 23 fishponds. Nutrient removal, retention and discharge of the fishponds, the total amounts of N, P and OM of inputs (fish feed, stocked fish, supplying water) and outputs (harvested fish, effluent water) were estimated and the nutrient budgets were calculated, based on the mass balance concept. The OM content of water was calculated from the volatile suspended solids (VSS).

The average N, P and OM concentrations and its range (in brackets) in the filling-up water of the fishponds were 2.51 (2.03-3.95), 0.57 (0.223-1.79) and 23.8 (6.94-42.6) mg l⁻¹, respectively. Contrarily, the N, P and OM concentrations in the effluents were 1.64 (0.431-9.23), 0.37 (0.093-0.682) and 30.2 (10.5-74.3) mg l⁻¹, respectively. The retained nutrients represented on average 53% (83.6 kg ha⁻¹ year⁻¹) of N, 74% (20.8 kg ha⁻¹ year⁻¹) of P and 74% (2427 kg ha⁻¹ year⁻¹) of OM introduced into the fishponds. Comparing the nutrient amounts in the pond effluents and inlet waters, the investigated fishponds discharged on average 48% less N and 62% less P into the recipient waters than received with the intake water. However, 78 % more OM was discharged with the effluent from the fishponds than received with the inlet and supplement water. In the fishponds, the ratio of input N, P and OM accumulated in fish biomass was 18.4%, 10.4% and 6.8%, respectively. Our observations show that the traditional pond fish culture is one of the few animal husbandry methods which typically have minimal deterioration effect on the environment.

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Analysis and determination of cadmium in shrimp marketed in Iran

MOHAMMAD ALI GOUDARZI

Faculty of Veterinary Medicine, Islamic Azad University of Shahr-e Kord Branch, Shahr-e Kord, Iran. Email: Goudarzi_vet@yahoo.com.

While cadmium can be tolerated at extremely low concentrations, it is extremely toxic, persistent and not easily biodegradable and high contaminated food may cause health risks to human. Heavy metals are considered the most important constituents of pollution from the aquatic environment because of their toxicity and accumulation by marine organisms. The objective of this study was to determine cadmium concentration in marine shrimp samples in Iran.

A total of 45 freshly caught shrimp were collected in three provinces (Booshehr, Hormozgan and Khoozestan) along the Persian Gulf in the south coast of Iran. Shrimp were collected at the end of each month from July 2008 to July 2009. Cadmium concentrations were determined by graphite furnace atomic absorption spectrophotometry, after digestion by the standard methods of AOAC.

In this study the mean, lowest and highest cadmium levels in samples were 0.25 µg g⁻¹, 0.08 µg g⁻¹ and 1.17 µg g⁻¹, respectively. Cadmium concentrations varied significantly ($p < 0.05$) in different seasons. No significant differences in cadmium concentrations of shrimp samples were observed between the three provinces. The results of this study indicate that tuna fish of produced and marketed in Iran have concentrations well below the standards WHO levels of these toxic metals.

High efficiency in ammonia uptake of marine microalgae *Tetraselmis chui* and its application in Mozambique tilapia (*Oreochromis mossambicus*) culture

AN-CHIN LEE, SHIH-YUAN CHEN, CHUN-NAN CHEN, CHI-JUI LIN

Department of Aquatic Biosciences, National Chiayi University, Chiayi 600, Taiwan, Province of China. Email: aclee@mail.ncyu.edu.tw.

This approach compares the efficiency in total ammonia nitrogen (TAN) uptake of four species of marine microalgae (*Nannochloropsis oculata*, *Isochrysis aff. galbana*, *Chaetoceros muelleri* and *Tetraselmis chui*) under different temperatures. The efficiency of TAN uptake of *T. chui* was the highest among these four species of microalgae at temperature levels tested. Its uptake (9.41 mg TAN/L.day) at 25°C was greater than that (4.58-5.67 mg TAN/L.day) at other temperatures. There is no significant difference in the growth rate among four species of microalgae at 25°C. Biomass production in dry weight of *T. chui* (85 mg dry weight/L.day) was higher than that of *I. galbana* (43 mg dry weight/L.day), of *C. muelleri* (39 mg dry weight/L.day) and of *N. oculata* (28 mg dry weight/L.day) at 25°C. Although the rate of specific TAN uptake by *N. oculata* was higher than that by *T. chui*, biomass production in dry weight of the latter was much higher than that of the former. This is why the efficiency in TAN uptake per unit volume of *T. chui* was higher than the others. This approach indicates that *T. chui* is a good choice for use to remove ammonia from pond water in marine fish farms. We also provide an evidence that 37.5 % of daily exchange rate of water was recovered by using *T. chui* to remove ammonia from the system.

Keywords: TAN removal, marine microalgae, growth rate, algal biomass production

Environmental sustainability of fish cage aquaculture in large hydroelectric reservoirs

GIANMARCO S. DAVID¹, EDMIR D. CARVALHO², ALEXANDRE N. SILVEIRA³, MILTON DALLAGLIO-SOBRINHO⁴, DANIEL LEMOS⁵

1. São Paulo State Agribusiness Technology Agency, Barra Bonita, Brazil; 2. Fish Biology and Ecology Laboratory, São Paulo State University, Botucatu, Brazil; 3. Dept. of Biology and Animal Science, São Paulo State University, Ilha Solteira, Brazil; 4. Dept. of Civil Engineering, São Paulo State University, Ilha Solteira, Brazil; 5. LAM Aquaculture Laboratory, Oceanographic Institute, University of São Paulo, São Paulo, Brazil. Email: dellemos@usp.br.

In the past fifty years most of large Brazilian rivers have been transformed into cascades of hydroelectric reservoirs with low fishery production. Several attempts of stock enhancement

were carried out, including tilapia stocking, though these artificial ecosystems have persisted very likely to biological deserts. In the past fifteen years cage aquaculture has shown to be economically feasible, mainly based on tilapia farming. The upper Paraná River basin drains the most industrialised and populated portion of South America, located at the Northern portion of Plate River basin. The total area of reservoirs in this region is over 500,000 ha, with a potential for fish production of more than 2 million metric tons per year by using 0.5 % of the total area. The sustainability of cage aquaculture depends on the harmonisation between farming practices and the hydrological particularities of the proposed site. Carrying capacity is determined by intrinsic characteristics of each site, such as water exchange rate, initial water nutrient content, sedimentation and depth. The determination is mostly based on geomorphological and limnological data of the sites to be used for cage aquaculture. For instance, the simulated carrying capacity for tilapia cage-culture in two sites (20°16'S; 50°58'W and 20°18'S; 51°58'W) in the same reservoir and with similar areas (31.6 and 30.8 km², respectively), but different water retention times (33.0 versus 21.6 days, respectively) and mean depths (6.0 versus 10.4 m) were very different (3,982 versus 7,768 metric tons per year), even though the more productive site displayed higher initial phosphorus (12.7 versus 16.1 mg/m³). Model calculations assumed a standard emission of 13.5 kg of phosphorus per ton of produced tilapia based on average 1.5 FCR and 1.5% total phosphorus feed content but feed management could drastically affect total allowable fish production. Simulating a 20% FCR increment, from 1.5 to 1.8, phosphorus emission would increase by 25% (18.0 kg P/metric ton of fish produced) resulting in a proportional reduction in the compatible production according to site carrying capacity. On the other hand, the increment of 6.7% in phosphorus feed content (to 1.6% total feed P) would result in a 9% decrease in total allowable production in the farming site. The limits for cage aquaculture expansion in reservoir sites employed detailed limnological field surveys, including bathymetry, hydrodynamics, water temperature, conductivity, dissolved oxygen, turbidity, chlorophyll a, total phosphorus and nitrogen, carried out in 19 sites in the last four years. Some reservoir sites registered significant nutrient increase related to cage farming, although apparently not enough to reach the eutrophication threshold due to limited scale of farming operations. Seasonal variations in hydrological features were relevant, with reduction in the carrying capacity related to massive nutrient influx from agricultural and sewage runoff, especially in summer, when water temperature is more favourable for tilapia farming.

Proportional charges on emission of nitrogen and phosphorus from effluents of freshwater aquaculture systems: fish, prawn, and frog farming

JULIO VICENTE LOMBARDI, CACILDA THAIS JANSON MERCANTE

Scientific Researchers of Fisheries Institute – APTA – SAA – SP – Brazil.

Email: lombardi@pesca.sp.gov.br.

Three commercial farms of freshwater aquaculture (fish, prawn, and frog farming), located in Sao Paulo State – Brazil, were analysed during a complete cycle of growing, in order to evaluate charges on emission of nutrients from effluents, specially nitrogen (N) and phosphorus (P). All of those farms were selected through the main criteria of being in accordance with the BMP - best management practices, and due to the adoption of conventional technologies, well recognised and recommended for the production of the following organisms in commercial scale: fish farming (Nile tilapia - *Oreochromis niloticus*), freshwater prawn farming (Malaysian prawn - *Macrobrachium rosenbergii*), and frog farming (bullfrog - *Lithobates catesbeianus*). The study was based on monthly samples collected in each aquaculture farm, with data of water quality (physical and chemical variables analysed in situ and in laboratory) and volumes of effluent discharge, as well as information about feed management and data of final production (fish, prawn or frog). Charges on the emission of N and P were calculated through the arithmetic subtraction of data registered at the water outlet (effluent) and at the water inlet. Results were analysed according to the total volume of effluent discharge, as well as the production of each aquaculture system. The total volumes of effluent discharge, equivalent to the production of one kilogram of aquaculture product, were: 16.54 m³ (fish), 8.44 m³ (prawn), and 4.23 m³ (frog) - approximate proportion of 4:2:1, respectively. Total charges on emission of N from effluents, analysed proportionally to the production of each aquaculture farm were: 22.74 kg (fish), 35.88 kg (prawn), and 13.14 kg (frog), equivalent to the production of one kilogram of aquatic organism. In the same way, total charges on emission of P from effluents were: 36.54 kg (fish), 8.24 kg (prawn), and 13.08 kg (frog). As conclusion, the present study has demonstrated that, for the specific conditions analysed, the proportional potential risks of environmental contamination, could be estimated in the following way: fish farming > prawn farming > frog farming, in terms of relative volume of effluent discharge; prawn farming > fish farming > frog farming, in terms of relative charges of N; and fish farming > frog farming > prawn farming, in terms of relative charges of P.

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A system dynamics model for designing ecological engineering of fish ponds towards optimising production in Tawa Command area of India (M.P.)

ALKA PARASHAR, S.K. PARASHAR, SHOBNA BAJPAJ MAROO

Sarojini Naidu Gov't Girls P.G. (Auto.) College, Bhopal, India.

Email: alkaparashar_2007@yahoo.com.

Agriculture-aquacultures are ancient practices in Asia. Simulation of these systems have been described as illustration of many important 'eco-techniques' applicable for ecological engineering. To date, extensive research has been conducted on the subject but mostly concentrating on the aggregate production. As a result, little is known about the process and interactions among various components in such ecosystems. In the present investigation, a field experience of water logged pockets of Tawa Command area of Madhya-Pradesh (India) was taken as a case to develop a simulation model using principles of system dynamics. Tawa a major irrigation project of Madhya Pardesh, India of the Narmada basin development, across Tawa River. After commissioning of the project, entire district has sufficient irrigation facility but water logging resulting through this project has been identified as a menace. The model is designed to evaluate the causal relationships, interactions and functioning of pond ecosystem for fish growth. The model replicates the interactions between the growth of phytoplankton, zooplankton and fish. The model is an aid to gain more insight into the biological process and forcing functions of various factors such as dissolved oxygen, temperature, pH, light in terms of fish growth, nutrient dynamics and flow of energy in a pond ecosystem. Fish production, consumers liking and fish marketing are incorporated into the model so as to evaluate the socio-economic environmental status of the region. The paper also addresses the potential of system dynamics modeling in generating various policy options for the maintenance of ecological health of fish ponds and also the interventions of various policies in the model provides strategic planning to farming the water logged land of command area in a sustainable manner for livelihood and food production.

Rehabilitation and conservation of threatened fish mahseer (*Tor tor*) in M.P., India

JYOTI SHARMA, ALKA PARASHAR, S.K. PARASHAR, SHOBHNA BAJPAJ MAROO

Sarojini Naidu Government Girls P.G. (Autonomous) College, Bhopal, India.

Email: palki87@yahoo.co.in.

India is a large land mass situated in the tropical zone and is blessed with a very rich and diverse aquatic resources in the form of rivers, streams, estuaries, reservoirs, lakes and ponds with a network distributed all over 1,600,000 km. A number of endemic species of fishes dominate both lentic and lotic waters. Madhya Pradesh (M.P.), the central state of India, is situated in the central plateau with Aravali, Vindhya, Satpura hill ranges. River Narmada considered as the lifeline of the state originates from hills of Amarkantak and stretches 1,280 km draining through three states and reaching Gulf of Cambay. Among many varieties of fishes found distributed in this river is mahseer of the Family Cyprinidae have been considered as the most prized treasure of Narmada. Mahseer is primarily an inhabitant of the rocky mountainous part of the perennial streams of India. They are found in deep still pools without a rock in them. So far, four species of mahseer have been reported in M.P. Among them *Tor tor* dominates in Narmada basin. Mahseer the King of mountain streams is commonly known as 'badas' and is indigenous to the Narmada. But despite their abundance at one time Mahseer have declined very rapidly were feared to be in danger of extinction in some parts of the country. The main reasons of depletion of mahseer are indiscriminate fishing, destruction of spawning and nursery grounds, habitat destruction, aquatic pollution, introduction of exotic species etc. However, in view of its depleting stock, an attempt is made in the present investigation for the conservation and rehabilitation of mahseer (*Tor tor*). Length weight relationship, morphometric measurement and gut content analysis of *T. tor* present in its natural habitat i.e. Narmada is made along with the analysis of water quality parameters, food and feeding habit of fish. Mahseer travels long distances for its food and breeding. Mahseer feeds on planktonic organisms and organic bottom debris and keeps it clean and potable. Fingerlings collected from river Narmada near Honshagabad (M.P.) were introduced into cages installed at Kerwan. Cage culture technology, offers the best option available to enhance the fish production from such water bodies. Fingerlings of *T. tor* can be raised to maturity in captivity in small ponds and in cages by following improved aquaculture practices. Fingerlings collected from Narmada were also introduced into a pond at Powerkheda fish farm, M.P. and a comparative study was made with mahseer found in Narmada and mahseer in cages installed at Kerwan.

Pelagic and benthic ecosystem functions under aquaculture induced nutrient stress - importance of water flow regime for scales of nutrient transport, storage and mineralisation

ANDREW K. SWEETMAN, TRINE DALE, KARL NORLING

Norwegian Institute for Water Research

The Norwegian coastal zone is impacted by a variety of non-point (e.g. agriculture,) and point-stressors, such as aquaculture. Net-pen fish farming in Norway has increased dramatically in the last two decades and as of 2005, reported aquaculture production stood over 600,000 tonnes. Successful, environmentally-friendly coastal management strategies need to be able to sensibly site farms along the coastline. This is particularly important today given that the aquaculture industry is growing and new fish-farm locations need to be proposed. Suitable management policies do however require a detailed understanding of how pelagic and benthic ecosystems operate under nutrient stress and how physical factors such as hydrodynamic regime influence ecosystem processes-all of which are poorly known.

The overall goal of this project is to quantify pelagic and benthic ecosystem responses to aquaculture induced stress in high and low-water flow regimes. This goal is currently being realised by the integration of three distinct work packages. In these work packages, we will measure fish farm waste release by quantifying growth rates and nutrient storage in micro-, macroalgae, and mussels as well as particulate material flux. In the benthic zone, we are evaluating total benthic and microbial metabolism around fish farms and at reference sites, and exploring faunal biodiversity and quantifying ecosystem functioning using powerful stable isotopic pulse-chase experiments.

This study comprises a sub-project within the larger 'Ecosystem Responses to Aquaculture Induced Stress' (ECORAIS) initiative that is funded by the Norwegian Research Council, and which is being co-led by the Norwegian Institute of Water Research, Institute of Marine Research, UNIFOB and the University of Bergen. Collaborating universities and institutes include the University of Southern Denmark, University of Gothenburg, and the Netherlands Institute of Ecology. The first studies took place in March 2010, and in-depth descriptions of the various work packages as well as new data from the first benthic experimental campaign will be presented.

Dispersal and accumulation of mariculture waste in the surrounding environment: the importance of site selection

SALVATRICE VIZZINI, VALERIA ANTONIA TUMBARELLO, MARIA VITTORIA CANGIALOSI, ADELE ELISA ALEO, ANDREA SAVONA, LUCA MICCHICHE, ANTONIO MAZZOLAR

Laboratory of Marine Biology and Sea Resources, Department of Ecology, University of Palermo, via Archirafi 18, 90123 Palermo, Italy

The development of aquaculture has caused great concern over the management and protection of coastal environments, as aquaculture activities can have a number of negative effects on marine ecosystems. Many descriptors have been used in the past to investigate the presence, dispersal and effects of aquaculture waste. Recently, stable carbon and nitrogen isotopes in sediments have been successfully used to detect the extent of waste dispersal in the marine environment, as they are able to give details about the origin of organic matter. At the same time, biochemical parameters of sediments, such as the RNA to DNA ratio, have been widely employed to evaluate the effects of organic enrichment on the functioning of the microbial system.

In this study we investigated sediments from two Sicilian (Italy, Mediterranean) fish farms, in terms of stable carbon and nitrogen isotope ratios and RNA:DNA. The fish farms were located in the northern and southern coasts of Sicily. The first (FF1) was sited at about 2000 m from the coast and at a depth of about 30 m; the second (FF2) was sited within a port and at a depth of about 25 m. Sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*) were reared in both fish farms. Sediment was sampled in two periods (summer and winter 2009) in seven stations selected at increasing distances from the cages, in both fish farms.

Lower variability was found in the isotopic composition for sediments from FF1 (range of $\delta^{13}\text{C}$: -23.8/-21.1‰; range of $\delta^{15}\text{N}$: 2.3-5.4‰) than FF2 (range of $\delta^{13}\text{C}$: -25.4/-20.5‰; range of $\delta^{15}\text{N}$: 1.0-6.4‰). At FF1 the stations more distant from the cages had $\delta^{15}\text{N}$ values similar to or higher than those of the cage stations, demonstrating the lack of accumulation of ^{15}N -enriched organic matter and then the low content of material derived from the fish farm. Conversely, at FF2 the stations close to the port and fish farm had more ^{15}N -enriched values than stations outside the port, suggesting the accumulation of aquaculture-derived organic matter in the area interested by fish farming.

The RNA to DNA ratio in the sediment from FF1 showed values next to one, indicating good conditions of the microbial community, a part from the stations placed just under the cages where the ratio had lower values (about 0,4). In all the stations from FF2 the ratio was far below one (from 0,1 to 0,2), indicating the presence of altered microbial communities.

In conclusion, in one site (FF1) the localisation of the fish farm in the open sea and the consequent moderate hydrodynamic conditions determined the dispersal and dilution of waste, while in the more confined site (FF2) the lower hydrodynamic regime promotes the accumulation of aquaculture-derived organic matter all over the area. These results corroborate the importance of the choice of the site where to carry out aquaculture activity, in order to prevent the accumulation of organic matter in the sediments and consequent alterations in benthic communities.

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Exploration of biomarkers for environmental stress in disc abalone using cDNA microarray

QIANG WAN, JEHEE LEE

*Department of Marine Life Science, Jeju National University, Jeju, 690756, Republic of Korea.
Email: oneqiang@msn.com.*

Disk abalone *Haliotis discus discus* is one of the most valuable mariculture species in East Asia, as well as an important component of coastal ecosystems. In everyday life of living in marine environment, abalones are exposed to a variety of stresses. These stresses could be caused by several physical factors such as the variations of temperature, salinity, light condition and dissolved oxygen, or caused by chemical pollutants due to human activity such as heavy metals and endocrine-disrupting chemicals. In our previous work, a normalised cDNA library of disk abalone was constructed. 5,996 clones were successfully sequenced and assembled into 1,019 contigs and 3,343 singletons. A total of 4,362 unique transcripts were obtained and compared against NCBI database by BlastX program. On the basis of these genes, 4K cDNA chips were constructed and used for screening of biomarker genes that respond to various physical and chemical stresses in this present study. After acclimation to laboratory condition (20°C, 32 ppt), abalones were challenged to heat (30°C), cold (4°C), hypersalinity (40 ppt), hyposalinity (25 ppt), cadmium, copper, mercury, beta-naphthoflavone, aroclor-1254 and TBT, respectively. The global gene response in gill and hepatopancreas of abalone was then estimated by 4K cDNA chips. Among physical stresses, heat stress caused the strongest influence in global gene expression with over 300 genes altered over 2-fold. In contrast, cold stress influenced approximately 200 genes and salinity stress significantly changed less than 100 genes. In chemical stresses, the strongest transcriptional effect was observed in the treatment of cadmium where over 200 genes were induced or repressed by over 2-fold. Copper and mercury also significantly regulated over 50 genes. However, only about 30 genes showed over 2-fold alteration in response to three endocrine disrupting chemicals. To sum up, we identified totally over 400 genes that are potentially involved stress response system of disk abalone and could be used as biomarkers. Nevertheless, it is noteworthy that a large portion of these stress-responding genes were still with unknown functions, which require our further efforts to characterise in future.

HSP20 of disk abalone *Haliotis discus discus* as a novel universal biomarker of environmental stress

QIANG WAN, JEHEE LEE

Department of Marine Life Science, Jeju National University, Jeju, 690756, Republic of Korea.

Small heat shock proteins (HSPs) constitute the smallest members of HSP family, with a low molecular mass ranging from 9 to 43 kDa (majorly 14-27 kDa). They are considered to interact with a wide range of non-naive proteins and stabilise them against aggregation in an ATP-independent manner, creating a transient reservoir of unfolded protein for subsequent refolding by ATP-dependent chaperones like HSP90s and HSP70s. In addition to protecting organisms from thermal injury as molecular chaperones, small HSPs are also implicated in a number of fundamental cellular processes, diverse physiological functions and many human diseases. In this present study, we reported the cloning, functional characterisation and expression analysis of one novel small HSP gene, HSP20, from disk abalone *H. discus discus*. The abalone HSP20 encodes a polypeptide of 160 amino acids, with an 18.76 kDa molecular mass and a putative PI of 5.82. Its deduced amino acid sequence showed the highest similarity with a group of invertebrate HSP20 genes. Through sequence analysis, we identified several signature features of small HSPs in abalone HSP20, including conserved α -crystallin domain, cysteine-free, Glx-rich and compact β -sandwich structure in C-terminal region. To understand the biochemical function of abalone HSP20, We sub-cloned it into pET16b vector and transformed into *E. coli* BL21 (DE3), followed by thermo tolerance assay. We observed enhanced thermo tolerance of *E. coli* cells by over-expressing abalone HSP20, suggesting its function in the cellular chaperone network. In expression analysis, we investigated the expression patterns of HSP20 under the challenges of different environment stressors by quantitative RT-PCR. Not only was dramatically induced by heat shock (30°C), the expression of abalone HSP20 was also significantly elevated by cold shock (4°C), extreme salinity (20 and 45 ppt), heavy metals (Cd, Cu and Hg) and endocrine disrupting chemicals (β -NF, B[a]P, Aroclor and TBT). Taken together, the above results indicate abalone HSP20 strongly involved in stress response system of abalone and hence able to be a universal biomarker of environmental stress.

Ecological characteristics of phytoplankton community in chloride typed saline-alkaline ponds of *Litopenaeus vannamei*

HUI WANG, ZONG LI YAO, KAI ZHOU, QI FANG LAI

East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Key and Open Laboratory of Marine and Estuarine Fisheries, Ministry of Agriculture, Shanghai, China.

Saline-alkali water areas are widely distributed in China. Of 45.87 million ha of saline-alkali water areas, chloride typed saline-alkaline water is one of the better utilised type. Phytoplankton are not only the natural food of larval shrimp but also play an important role in water quality control. Investigation of phytoplankton structure and dynamics in chloride typed saline-alkaline ponds culturing *Litopenaeus vannamei* were conducted at Huanghua City in Cangzhou during May to September 2004. 39 genera 59 phytoplankton species were identified. The dominant phytoplankton groups are chlorophyta (including 17 genera, 23 species, and accounted for 38.98%), Bacillariophyta (8 genera 14 species, represented 23.73% of the total) and Cyanophyta (6 genera 11 species, represented 18.64%). The abundance of Euglenophyta and Chrysophyta were relatively low representing only 6.78% and 5.08%, respectively. The phytoplankton component varied with the change of seasons. Chlorophyta, Cyanophyta and Euglenophyta appeared mainly between July and September; Chrysophyta and Pyrrophyta appeared mainly between May and June; Bacillariophyta appeared in the whole culture period from May to September. In conclusion, most of the phytoplankton species in saline-alkaline pond are euryhaline, and the structure and dynamics varied with the different seasons and water chemical factors such as salinity and carbonate alkalinity.

Rice field for the treatment of pond effluents

CONGXIN XIE, XUGANG HE, DAPENG LI

1. College of Fisheries, Huazhong Agricultural University, Wuhan, China; 2. Key Laboratory of Freshwater Biodiversity Conservation and Utilization of Ministry of Agriculture, PR China. Email: xiecongxin@mail.hzau.edu.cn.

In order to investigate the removal efficiency and its response on different fertiliser treatments concerning the rice field for pond effluent treatment, an experiment with four treatments was conducted: without rice planted as the control (CT), rice planted without fertiliser input (RE), rice planted at about a rate of $1.0 \text{ g m}^{-1} \text{ d}^{-1}$ potassium chloride application (RK), rice planted and mineral fertiliser ($\text{N}:\text{P}_2\text{O}_5:\text{K}_2\text{O} = 0.6:0.5:0.8$) applied before the experiment (RF). Inflow and effluent water from the treatments were monitored weekly.

The evaluated water quality parameters were: total phosphorus (TP), dissolved phosphorus ($\text{PO}_4^{3-}\text{-P}$), total nitrogen (TN), ammonia-nitrogen ($\text{NH}_4^+\text{-N}$), nitrate-nitrogen ($\text{NO}_3^-\text{-N}$), nitrite-nitrogen ($\text{NO}_2^-\text{-N}$) and chemical oxygen demand (COD). Evaluations for plant height and yield were performed at the end of the experiment. Under different fertiliser treatments, high average removal rates of TN, TP and COD were obtained, over 56%, 68% and 53% respectively, and showed no significant differences ($p > 0.05$), indicating that the rice field could remove the pollutant effectively and different fertiliser treatments had no impact on removal efficiencies. However, different fertiliser treatments showed significant differences in rice yield ($p < 0.05$). The RF treatment gave the highest production of $649.53 \pm 94.2 \text{ g m}^{-2}$ and the RK $523.83 \pm 71.5 \text{ g m}^{-2}$ intermediately, increased by 42.93% and 15.27% than the RE respectively, indicating that fertiliser treatments had a significant effect on the rice yield. Rice field can purify pond effluents efficiently without a reduction in production when appropriate mineral fertiliser applied.

Keywords: rice field, pond effluent, nutrient removal, aquaculture

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Effect of L- carnitine enrichment on the population growth of the cladoceran *Daphnia longispina*

SEVGI SAVAS, MURTAZA ÖLMEZ

*Süleyman Demirel University, Faculty of Fisheries, E irdir-Isparta-Turkey.
Email: segi68@yahoo.com.*

Effect of L-carnitine enrichment on the population growth, reproductive age and individual growth of *D. longispina* a potential alternative live food for fish larvae was determined. Cladocerans were enriched with 10 levels (0, 0.001, 0.01, 0.1, 1, 10, 100, 500, 1,000 and 1,500 mg L-carnitine per l) of L-carnitine supplements dissolved in *Chlorella vulgaris* culture medium in a 30 ml individual culture trial for 26 days. The trials were conducted $1.5 \times 10^6 \text{ cell ml}^{-1}$ at food density, at $20 \pm 1^\circ \text{C}$ under an axenic condition in the laboratory. The results have demonstrated that supplemented L-carnitine in culture medium resulted in significant ($P < 0.05$) responses in reproduction age, population growth rate of enriched cladocerans. The increase of population density was detected in 0.1-10 mg l^{-1} L-carnitine-treated cladocerans but the highest population density ($P < 0.05$) was detected in 1 mg l^{-1} L-carnitine treated cladocerans in this study. *D. longispina* enriched with 100, 500, 1,000 and 1,500 mg l^{-1} L-carnitine treated with the cladocerans 100% mortality at the first day.

The results suggest that L-carnitine could be a positive factor to enhance reproduction and population growth on enriched *D. longispina* directly or/and indirectly under the optimum concentration.

Keywords: L-carnitine, D. Longispina, enrichment, population growth

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Harpacticoid copepod *Euterpina acutifrons*, a potential live feed for marine finfish larvae

SITTI RAEHANA MUHAMAD SHALEH, MARLENA AMATUS, ROSSITA SHAPAWI

Borneo Marine Research Institute, University Malaysia Sabah, Locked Bag 2073, 88999 Kota Kinabalu, Sabah, Malaysia. Email: sittirae@ums.edu.my.

The survival and development of larvae are directly influenced by the supply of live feeds. Copepods are one of the most important live feed for the marine finfish larval stage. Copepods nauplii are essential food for larvae rearing as it has higher nutritional value, broad size range, high digestibility and are slow swimmers. However, unlike rotifer culture, copepods are difficult to culture at sufficient densities on a commercial scale. Thus, to satisfy the growing demands of marine finfish larviculture, research into development and the culture of copepod is urgently needed. In this study, *Euterpina acutifrons* a pelagic harpacticoid copepod was successfully isolated from Sepanggar Bay, Kota Kinabalu and maintained in the laboratory. Harpacticoid copepods are among the most preferred prey for aquaculture as they promote faster growth in finfish larvae compared to rotifers and artemia and they are naturally rich in essential fatty acids. For maximum copepod production, study on the effect of algal diet on the growth of *E. acutifrons* was conducted. Diatoms were found to be the best microalgal diet for *E. acutifrons*. However, the population growth was significantly higher with mix algal diets compared to mono-algal diets.

Keywords: harpacticoid copepod, Euterpina acutifrons, live feed, aquaculture

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SEP-ART: Innovative, economical and sustainable automation of live food production in hatcheries

G. ROMBAUT¹, E. NAESSENS¹, D. GRYPONPRÉ¹, L. VAN NIEUWENHOVE², C. VERMOTE¹

1. INVE Technologies NV, Hoogveld 93, B-9200 Dendermonde, Belgium; 2. INVE Aquaculture, 471 Bond Street, Nonthaburi 11120, Thailand. Email: c.vermote@inve.be.

Use of live food is vital for the successful early development in larviculture of many marine finfish and shellfish species (Kolkovski et al., 2004). The brine shrimp *Artemia* is the most widely used live food constituent in a larviculture feeding regime as a result of its high nutritional quality (Sorgeloos et al., 1986). *Artemia* is available on the market as stable

cysts, which when exposed to seawater, hatch and release free swimming nauplii and empty cyst shells. The non-hatched cysts and their shells may not be digestible and could lead to increased mortality by blockage of the gut. Hence, the hatchery operator needs to separate the freshly hatched brine shrimp nauplii from the cyst shells. This is a complex and time consuming process consisting of multiple steps, often using sedimentation, sieving and/or decapsulation techniques.

In chemical decapsulation, sodium hypochlorite and caustic soda are used to oxidise and remove the shells, whereby cyst colour and temperature of the bath are closely monitored. This process gives rise to high levels of organic chlorine compounds (incl. AOX), some of which are toxic for aquatic organisms and can be persistent environmental contaminants. In addition to environmental safety, there are also human safety concerns since chlorine gas is released.

We have now developed an innovative one-step approach to readily and gently separate nauplii and shells. SEP-Art technology (patent pending) allows for a very efficient, easy-to-use, safe and environmentally friendly separation of the *Artemia* cyst shells: i) *Artemia* cysts receive a non-toxic magnetic coating, ii) after hatching the cyst shells are removed by a separating flow-through device.

By using SEP-Art, the output of nauplii that are still alive and undamaged after the separation step can be increased with 30% to 60% (as dry weight biomass). This result, obtained regardless of *Artemia* cyst origin or hatching efficiency, is the result of both an increase in separation efficiency, and a reduction of *Artemia* nauplii mortality. Using the gentle SEP-Art system, nauplii mortality is less than 2%, whereas nauplii mortality can be as high as 20% with the classical separation techniques. This increase in productivity ultimately results in economically gains for hatcheries worldwide.

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Cloning and sequence analysis of the full length cDNA of *rbcL* from *Ulva linza* (Chlorophyceae; Chlorophycophyta)

CHENG-QI YING^{1,2}, SHUN-JI YIN¹, SEN-JIE LIN², SHEN-YI¹, PEI-MIN HE¹

1. Key Lab of Aquatic Genetic Resources & Aquacultural Ecology, Ministry of Agriculture, Shanghai Ocean University, Shanghai 201306, China; 2. East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Shanghai 200090, China; 3. Department of Marine Sciences, University of Connecticut, Groton, CT 06340, USA.

Rubisco (ribulose 1,5-bisphosphate carboxylase/oxygenase) is the first key enzyme in the photosynthesis pathway. In this study, the full length cDNA, encoding rubisco large subunit (RbsL) was cloned from *Ulva linza* for the first time. Partial *rbcL* cDNA sequence of 1101 bp was first cloned by RT-PCR from total RNA, then, both sequences at 3' and 5' ends

were amplified using 3'-RACE and 5'-RACE technologies that yielded 579 bp and 371 bp DNA fragments, respectively. A full length cDNA sequence of 1472 bp was obtained from these cloned sequences and was assigned to a new NCBI accession number DQ813496. It contained the 1425 bp full coding sequence for rubisco large subunit (RbsL) and a leader sequence of 47 bp, and it encoded a protein of 474 amino acids. Through bioinformatic analysis and BLAST search, the full cDNA sequence in *Ulva linza* showed high homologies to known full length cDNAs of the same gene from other green algae where rbcL cDNAs were previously cloned. The identity ranged from 82.07% to 85.78%, and 88.00% to 94.11%, respectively, at DNA and amino acid levels. The highest homology of the protein was obtained between *Ulva linza* and *Chlorella pyrenoidosa*. Based on the newly identified cDNA sequence, multiple alignment was performed by using bioinformatic software among amino acid sequence of *Ulva linza* and other two higher plants and one green alga. Then, the secondary and three-dimensional structures for Rubisco large subunit in *Ulva linza* were also predicted and analysed with online programs.

Keywords: rbcL; Ulva linza; leader sequence; RACE; cDNA

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Production of oligosaccharides by a novel agarase producing marine bacteria *Saccharophagus* spp.

YU CHEOL KIM, JEHEE LEE

Department of Marine Life Science, College of Ocean Science, Jeju National University, Jeju, 690-756, ROK. Email: hanraoldman@hotmail.com.

Oligosaccharides are an important group of polymeric carbohydrates that have great economic values due to their physiological and biological activities. Many lines of evidence suggest that the oligosaccharides mixture exhibit antioxidative activities in scavenging ROS and inhibiting lipid peroxidation. In aquaculture, oligosaccharides have also shown to effect pathogen resistance and immune modulation of fish. According to several reports, a supplement of oligosaccharides in fish diets could significantly increase growth rate, reduce overall mortality and disease and improve feed conversion ratios. However, there is a need to achieve continuous and efficient production of oligosaccharides of low cost and high-purity, to meet the rapidly increasing demand in various fields such as aquaculture.

Agarase is able to cleave the beta-1,4-linkages between D-galactose and alpha-L-3, 6-anhydro-galactose residues in the red algal galactans known as agars. In this present study, we screened agarase producing marine bacteria from Jeju sea in Korea. We isolated genomic DNA from the bacteria and analysed 16S rRNA sequence by PCR and sequencing. The sequence was 99% (1376/1384 bp) similar to *Saccharophagus degradans* 2-40. The strain was grown in 5L marine broth including 0.5% agar at 30°C. Agarase protein was purified by ammonium precipitate, ion exchange chromatography and gel permeation

chromatography. We checked the agarase protein by SDS-PAGE and activity test. The size of agarase was about 75 kDa. Internal amino acid sequencing was carried out with purified protein. Enzymatic assay observed by thin layer chromatography that crude sample of the agarase broke to monomer oligosaccharides from agar. The ability of degradation of agar or agarose to oligosaccharides makes this novel marine bacteria possible to utilise in future oligosaccharides and thereby contribute to aquaculture development.

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Sex reversal in Siamese fighting fish (*Betta splendens*, Regan 1910)

KONSTANTINOS KIPOUROU, LOANNIS PASCHOS, GOUVA EVANGELIA, ERGOLAVOU ANNA, COSTAS PERDIKARIS

Department of Aquaculture & Fisheries, Technological Educational Institute of Epirus, Irinis & Filia 1, 46100 Igoumenitsa, Greece. Email: paschosi@otenet.gr.

Many species of ornamental fish, exhibit a marked sexual dimorphism due to the more pigmented bodies and larger fins usually observed in males. Due to this fact, the price of male fish is up to three times higher than the price of females. *Betta splendens* (Regan, 1910) is very popular among aquarists because of its splendour of colour. The culture of monosex (all-male) stocks of Siamese fighting fish could be of a significant economic advantage. The aim of the present study is to present the masculinisation of *Betta splendens* (Regan, 1910) with low doses of 17-alpha-methyltestosterone (MT). The oral administration of the hormone started 7 days post hatching divided into 4 groups of different administrative concentrations (1mg, 2mg, 3mg, 4mg/kg⁻¹), for an 8 weeks period. Use of MT feed at 3 and 4 mg /kg⁻¹ resulted in 100% masculinisation.

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Ferritin H subunit from rock bream, *Oplegnathus fasciatus*: cloning, characterisation and expression analysis

SUKKYOUNG LEE, JEHEE LEE

Department of Marine Life Science, College of Ocean Science, Jeju National University, Jeju, Republic of Korea. Email: lskshiny@hotmail.com.

Iron is an essential element required for the growth of almost all living organisms. Ferritin plays a key role in cellular iron metabolism, which includes iron storage and detoxification.

In vertebrate ferritins, there are two distinct polypeptide chain subunits: heavy (H) and light (L). The heavy and light chains are encoded by two different genes and expressed independently. H subunit possesses the ferroxidase centre and is responsible for iron oxidation. On the other hand, L subunit lacks ferroxidase activity but has several negatively charged residues on the inner surface of the ferritin shell that shape an intra-chain salt bridge and facilitate ferrihydrite nucleation. In this present study, we cloned a ferritin H subunit gene (RbFh) from rock bream (*Oplegnathus fasciatus*), a species of importance in aquaculture in Korea. The complete cDNA of RbFh contained 531bp open reading frame encoding a polypeptide of 176 amino acid residues. The tissue distribution of RbFh mRNA was examined by qRT-PCR and showed a ubiquitous expression in various rock bream tissues including gill, liver, spleen, blood, head kidney, kidney and skin. Recombinant ferritin H subunit was successfully expressed in *E. coli* BL21 (DE3) cells, and then purified by affinity chromatography using amylose resin. The molecular weight and purity of recombinant protein were determined by SDS-PAGE. Finally, the iron-chelating activity of the purified RbFh protein was measured.

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Study on some external and internal anatomic characteristics of three cyprinids fish species: grass carp, *Ctenopharingodon idella*, Benni, *Barbus sharpeyi*, and Shabout, *Barbus grypus*

RAHIM PEYGHAN, HEDAIATOLLAH RASHIDI, SEIEDE TAHERE SHAHIDI

Veterinary Faculty, Shahid Chamran University, Ahvaz-Iran. Email: rpeyghan@yahoo.com.

Cyprinids are a diverse family that their use in aquaculture and as tools in different investigations makes their systematic and anatomic identification very important. Grass carp is one of the most important species in warm water aquaculture in the world. In Iran, it is by far the most commercially important cyprinid, next to common carp, that is used in warm water aquaculture. On the other hand Benni and Shabout rank first in value among the freshwater species caught commercially in some areas i.e. southwest of Iran and Iraq. Adult specimens (25-35 cm long) of *C. idella*, *B. sharpeyi*, *B. grypus* (20 specimens from each species) were collected from the Karun river and one of the local fish farms. For each fish some external and internal morphological characters were compared and some morphometric characters were measured. Some morphologic characteristics external and internal organs of these fish species were studied and morphometric means of some important biological parameters such as the ratio of intestine length to total length, heart weight to body weight and total length to body weight were measured for these three fish species. ANOVA, analysis revealed a rather high morphological variability between the three species in some of the characteristics especially between grass carp and two other species. However, the ratio of intestine length to total length in grass carp was significantly lower than Benni and Shabout, but all the three species have a long intestine and the ratio and anatomical features of the digestive tract, are consistent with their herbivorous.

Study of anatomical and histological changes of hepatopancreas in shrimp, *Litopenaeus vannamei* during and after post larval stage

RAHIM PEYGHAN, HASSAN MOROVATI, AMIR RAHBAR

Veterinary Faculty, Shahid Chamran University, Ahvaz-Iran. Email: rpeyghan@yahoo.com.

Hepatopancreas is a vital and major organ of decapods including shrimps that combines the functions of liver, pancreas and intestines in vertebrates. Its main functions are storage of lipids, glycogen, minerals and other nutrients. Its functions change in some periods of shrimp life and this change reflects directly in the histological structure of the hepatopancreas. In this study 60 post larvae of *Litopenaeus vannamei* of three different ages (post larvae, 0.5-1 g and >1 g group) were caught from a local farm. After fixation in Davidson's solution, weighing and biometry of shrimps, the samples from hepatopancreas were processed by routine paraffin embedding and then sectioned at 5 µm. Tissue sections were stained with H&E and PAS and examined under a light microscope. The hepatopancreas of the three size groups exhibited a well-organised glandular tubular structure normally seen in adult shrimps. The number and size of tubules increased with size of the shrimp. A single layer of epithelial cells was found lining the tubules all three groups. The cells showed normal differentiation into E (embryonic) cells, young R (restzellen) cells and F (fibrillenzellen) cells, and B (blasenzellen) cells. In PAS staining for determination of glycogen storage, none of the cell groups were PAS positive. In the microscopic study of sections four kind of hepatopancreatic cells were observed. There were few tubules in the hepatopancreas of the first group but there was no significant change between the tubule diameters and cell sizes among the first group and the second group. It was noted that with the increase of body weight from the second group to third group there was a strongly significant increase in the number and size of tubules and also in the size of the cells.

Introduction of a sea cucumber species *Stichopus hermanni* (Echinodermata: Holothuroidea) from Kish Island, Iran

AKLAM TEHRANIFARD, JAMSHID YARABBI

Email: akram.tehnanifard95@gmail.com.

Holothuroids or sea cucumbers are an abundant diverse group of echinoderms with over 1400 species. They are high valued and play an important role in the ecosystem, preventing anoxic conditions in the sediment by removing organic matter. In this study, we report on a sea cucumber species *Stichopus hermanni* from Kish Island. It is brownish yellow often

mottled and with darker papillae giving a spotted appearance. This species inhabits shallow water and is common in reef habitats. It is widely distributed across the tropical Indo-Pacific region. *S. hermannii*, is a holothurian of the order Aspidochirotes belonging to the family Stichopodidae. It is a deposit-feeder and is mainly found on sandy bottom of fringing reefs surrounding the Kish Island.

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Distribution, population dynamics and characteristics of bacteria in five types *Litopenaeus vannamei* cultured water

KAI ZHOU¹, QI FANG LAI¹, ZHANG LUO², ZONG LI YAO¹, HUI WANG¹, DAI XIA XU², CHENG QI YING¹

1. East China Sea Fisheries Research Institute, Chinese Academy of Fisheries Sciences, Key and Open Laboratory of Marine and Estuarine Fisheries, Ministry of Agriculture, Shanghai, China; 2. Tianjin Centre of Prevention and Control in Aquatic Disease, Tianjin, China.

Distribution, population dynamics and characteristics of bacteria in five types *Litopenaeus vannamei* cultured water, such as freshwater, saline-alkali water, surface water, sea water and brine water were studied in Tianjin and Huanghua City. The results showed that population of heterotrophic bacteria, *Vibrio*, nitrifying bacteria, denitrifying bacteria and sulfate-reducing bacteria varied significantly in the five different types of water. The total numbers of heterotrophic bacteria in the five types decreased in the following sequence: sea water > brine water > surface water > saline-alkali water > freshwater; the total numbers of *Vibrio* as: brine > sea water > surface water > saline-alkali water > freshwater; the total number of nitrifying bacteria: sea water > surface water > saline-alkali water > freshwater > brine water; the total number of denitrifying bacteria: saline-alkali water > freshwater > sea water > surface water > brine water; the total number of sulfate-reducing bacteria: surface water = freshwater > sea water > saline-alkali water > brine water. The dominant microbial flora in freshwater were *Aeromonas*, *Plesiomonas* and Enterobacteriaceae, representing 21.34%, 18.57% and 17.14% of the total, respectively; The dominant microbial flora in saline-alkali water were *Alcaligenes*, *Vibrio*, Enterobacteriaceae, *Corynebacterium*, representing 29.27%, 19.51%, 14.63% and 14.63%, respectively; The dominant microbial flora in surface water were *Vibrio* and *Aeromonas*, representing 23.08% and 15.38%; The dominant microbial flora in sea water were *Vibrio* and Enterobacteriaceae, representing 19.35% and 16.13%; The dominant microbial flora in brine water were *Vibrio* and *Pseudomonas* representing 38.71% and 12.90%, respectively.

Certification for Aquaculture Professionals (CAP) program: A new tool for aquaculture training

ANTONIO GARZA DE YTA

Department of Fisheries and Allied Aquacultures, 203 Swingle Hall, Auburn University, Auburn, AL 36849, USA. Email: garzaan@auburn.edu.

The aquaculture industry is one of the fastest growing segments of agriculture in the world. Technicians are a critical component of the aquaculture value chain. Government agencies require specialists that have general knowledge of aquaculture activities, and can evaluate, develop, and improve aquaculture projects. Aquaculture ventures need specialists with knowledge of the current techniques and procedures. These professionals should be able to analyse economic, financial, biological, and ecological issues related to the industry.

In most countries around the world, especially those in tropical regions, there are not enough aquaculture specialists. The results are inadequately trained biologists occupying positions that require an aquaculture background. At best, the needs of the governments or the industry are not fulfilled and at worst, the potential economic opportunities of the industry are not being developed. This raises the need to create a world-wide training and certification program to guarantee a minimum knowledge for aquaculture professionals.

The Department of Fisheries and Allied Aquacultures at Auburn University has been recognised as a world leader in aquaculture education and training for many years. Thousands of aquaculturists have been trained through short-term and degree training programs. In keeping with this leadership role, Auburn University has envisioned being the first institution that trains and certifies aquaculture professionals around the globe through distance learning.

To accomplish this, a web-based Certification for Aquaculture Professionals (CAP) training program was developed. The objective is to provide a training and certification for aquaculture professionals that will allow them to excel in their jobs, and acquire deeper understanding of environmental, food safety, animal welfare, animal health and social responsibility issues. The program is principle-based so that it has application to all types of aquaculture operations around the world.

The CAP program provides a solid foundation to professionals in the aquaculture industry throughout the world. It will be a tool for government agencies and privately owned companies to enable their personnel to acquire the necessary training to perform their tasks with a solid understanding of the factors that influence the production of aquatic animals and the techniques to manage these factors for sustainable aquaculture.

The effects of different alkaline treatments on yield and quality of agar from *Gracilaria verrucosa* at southern Iranian coastal area, Persian Gulf

YOUSEF FILIZADEH, GELARE GODARZI

Department of Agronomy, Shahed University, P.O.Box: 18151/159 Tehran, Iran.

Email: filizadeh@shahed.ac.ir.

The effect of several alkaline treatments on the yield and gel strength of net cultivated *Gracilaria verrucosa* in a Coastal Province of the Persian Gulf, Iran was analysed. Different NaOH concentrations (1.5, 3.0, 4.5, 6.5 and 7.5%) and temperatures (70, 80 and 90°C) were used. All treatments lasted for 90 minutes. Results showed that the best treatment conditions were at 4.5 and 6% NaOH, and 90°C. Maximum gel strength (1,190 g cm⁻²) was obtained with 6.5% NaOH at 90°C after 90 minutes. This condition resulted in an agar yield reduction of 19.5% relative to native agar.

Keywords: Gracilaria verrucosa, Agar yield, Gel strength, Alkaline Treatment, Temperature.

The effects of alkaline treatment and seasonal variation on agar yield and gel strength of *Gracilaria corticata*

YOUSEF FILIZADEH¹, MAHDEA KARKHANE²

1. Department of Agronomy, Shahed University, P.O.Box: 18151/159 Tehran, Iran. 2. Islamic Azad University, Research and Science Unit, Tehran, Iran. Email: filizadeh@shahed.ac.ir.

Gracilaria corticata, at the southern Iranian coastal in the Persian Gulf, was harvested in order to determine the seasonal variation on yield and quality of native and alkaline agar during 2008–2010. The highest alkaline agar yield was obtained in winter (23%) and the highest gel strength in spring (1,360 gcm⁻²). The highest melting temperature was 90°C obtained in the winter. The highest gelling temperature was 65°C (spring). The best results in the agar yield during the agar extraction were obtained after 45 min of alkaline treatment with 5% sodium hydroxide.

Keywords: Gracilaria corticata, agar yield, seasonal variation, gel strength.

Indigenous traditional knowledge (ITK) in Indian fisheries

ARPITA SHARMA, RUPAM SHARMA, S.P. SHUKLA, SURESH BABU P.P., PARAMITA B. SAWANT, G. VENUGOPAL, D. KUMAR

Central Institute of Fisheries Education, Deemed University, Indian Council of Agricultural Research, Versova, Mumbai – 400061, India. Email: rupamsharma06@gmail.com.

Veds (Sanskrit véda, “knowledge”) are large body of texts originating from ancient India. The Vedas are the ancient scriptures or revelation (Shruti) of the Hindu teachings. They manifest the Divine Word in human speech. As per Indian intellects, the existence of Veds is time immemorial and it came into existence with the evolution of universe. But historians like Maxmuller, Jacob, Tilak have established its existence between 4000 to 2500 BC. Hence, they are very ancient and only in recent times has their spiritual importance realised. One of the Veds, i.e. the Rig Veds, are considered to be the earliest work according to many like Karpatri as mentioned in Ramayan Mimansa and according to modern historians, it is considered as the most ancient book in the world. In Rig Ved, Matsya or fish, mode of hunting of fishes (Muksija which means net for catching fish or animals) and the feeding habits of the people have been mentioned.

It has been reported that aquaculture has been operating in China circa 2500 BC. When the waters subsided after river floods, some fishes, mainly carps, were trapped in lakes. Nascent aquaculturists fed their brood using nymphs and silkworm faeces, and ate the fish for their protein. A fortunate genetic mutation of carp led to the emergence of goldfish during the Tang Dynasty.

In Atharv Ved, reference to fisheries has been made by narrating a legend in which a fish saves Manu from deluge. Vedas, Samhitas, Brahmanas, the Aranyakas, Upnishads contain several references of fishes. In India, the Pandyas, a classical Dravidian Tamil kingdom, were known for the pearl fishery as early as the 1st century BC. Their seaport Tuticorin was known for deep sea pearl fishing. The paravas, a Tamil caste centred in Tuticorin, developed a rich community because of their pearl trade, navigation knowledge and fisheries.

It is evident that fisheries and aquaculture was practiced in India since time immemorial. If we consider the existence of Ved as per the historians, then it can be stressed that the origin of fisheries has been from India. In fact, there are some reports where it is mentioned that the indigenous Australians of the Guditjmarra people in Victoria may have practiced the aquaculture of eels as early as 6000 BC. But this is not certain.

Thus, it becomes evident that the indigenous knowledge of fisheries in India exists since long and needs to be documented. Some efforts have been done by researchers to document the same but Central Institute of Fisheries Education (CIFE), Mumbai, India

has taken initiatives for proper documentation of these indigenous knowledge from all corners of the country. This is for the reason that fishers of India have a rich legacy of indigenous knowledge, traditional practices and customary rules and regulations. It is widely acknowledged that traditional knowledge of fishers and their community based management systems hold immense value for sustainable fisheries management. This knowledge developed from experiences, enriched over centuries and has been embedded in local cultures and traditions from generations to generations. The accumulated experiences of wisdom of the local fishers reveal their profound knowledge of aquaculture, aquatic environment and ecology as well as conservation and management of fisheries resources. However, due to lack of proper documentation these traditional knowledge remains confined within that particular community.

To achieve this goal CIFE has been organising participatory writeshops on 'ITKs in Fisheries Sector' in several aqua ecological zones of the country: North East, East coast, West Coast and in Central and Northern Zone. The first Inception Workshop was held in the North East region on 19-20 September, 2008 at Guwahati. Later on the writeshop was organised during 21st to 25th of April, 2009 at Shillong, Meghalaya to document the ITKs from the North-East region of India. For these writeshops, various resource persons were invited from different parts of that zone for contributing the ITKs and sharing the experiences. The ownership of the ITK remains with the communities practicing the ITK. The project team has already documented around 81 ITKs from the North East and around 75 ITKs from the East coast of India. From West coast of India around 125 ITKs have been documented.

In addition to that Seminar and a Writeshop on 'Pracheen Sahitya Mein Matsya Evam Matsyiki Sampada' at CIFE, Mumbai has resulted in draft document in a book format on documentation of fish and fisheries in ancient Indian literature.

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Tilapia: silent booming in Bangladesh

SK. AHMAD-AL-NAHID^{1,2}, M. MAHFUJUL HAQUE¹, MD. ABDUL WAHAB¹, DAVID C. LITTLE², FRANCIS MURRAY²

1. Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh; 2. Institute of Aquaculture, University of Stirling, FK9 4LA UK. Email: swan_bau@yahoo.com)

This study was part of a scoping study on commercially important aquaculture species traded from Asia into Europe under an European Commission (EC) funded project 'Sustaining Ethical Aquaculture Trade' (SEAT). The objective was to assess the current production status and development trends of four important species, one of them being tilapia. Methods included literature review and rapid rural appraisal (RRA) exercises in Comilla (important for flood plain tilapia culture), Chandpur (for cage culture), Pabna (for monoculture), Khulna (polyculture with shrimp and prawn), Jessore (polyculture with carps),

and Mymensingh (polyculture with catfish and carps) districts. During September 2009 to April 2010, 24 tilapia farms (4 per district; 2 small: farm size ≤ 0.20 ha, 1 medium: farm size 0.21 to 0.80 ha and 1 large: ≥ 0.81 ha in each instance), 6 tilapia hatcheries (1 per district), 6 markets (1 per district) and 2 processing plants (in Khulna) were visited. For this exercise, 24 Tilapia farmers, 6 hatchery owners, 18 retailers and 18 consumers (3 retailers and 3 consumers at each market) and 2 processors were also interviewed individually.

At present there are approximately 70 commercial tilapia hatcheries in the country, of which the first to start was a mono-sex tilapia seed production facility in Cox's Bazar in 1992. It was found that the increasing availability of tilapia seed made diverse positive impacts on traditional aquaculture practices.

Results demonstrated that tilapia has several encouraging attributes (e.g. suitable for culture in both fresh and brackish water, country-wide low cost seed availability, high resistant to diseases, high local market demand, comfortable price for both farmers and consumers, stable market price, two crops year⁻¹, cash flow round the year etc.) which collectively resulted in higher adoption at the farmers' level. It can be cultured in various densities and combinations from mono- to polyculture with carps, shrimp, prawn, or with catfish (*Pangasius*, *Heteropneustes* and *Clarias*), and in different containments including ponds, rice fields, gher (low lying wet lands used for shrimp and prawn), flood plains, river cages, tea garden ponds, small reservoirs etc. Moreover, tilapia has provided a strategic means for farmer households to mitigate cropping risks. *Pangasius* catfish farmers culture tilapia as an alternative, to compensate when catfish market price is low, while shrimp and prawn farmers stock tilapia to minimise diseases.

Impacts: With the expansion of tilapia production, there is a growing interest observed at the level of private entrepreneurs in exploring the potential of export markets. Increased knowledge of tilapia sex-reversal seed production, the positive attributes of culture systems and environmental impacts of culture will contribute to the development of EAFI (Ethical Aquatic Food Index). The broader understanding of a range of different issues will contribute to studies of other aspects of SEAT project and policy development.

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Aquaculture and economic development: does size matter?

BEN BELTON, DAVID C. LITTLE

*Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland, UK.
Email: bdb1@stir.ac.uk.*

'Small-scale' aquaculture has long been supported by international development institutions concerned with its ability to alleviate rural poverty. However, as aquaculture develops into an increasingly complex global food production system, labels such as 'small-scale' become

more problematic, and alternative interpretations of the relationship between aquaculture and poverty are increasingly apparent. This poster compares the impacts of conventional 'small-scale' homestead pond-based carp polycultures in Bangladesh with those of highly capital and resource intensive commercial *Pangasius* culture systems found in Mymensingh district. The implications of both are considered with respect to ease of market entry by the poor, employment creation, size of operations, and contributions to food security, and an alternative typology of aquaculture is introduced based on relations of production rather than scale.

Impact statement: This research provides a basis for formulating more effective evidence-based policy to enhance the contributions of aquaculture to economic development, poverty alleviation and food security.

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Development of auction markets (Chatal) as an additional tier in the value chain of farmed shrimp and prawn in Bangladesh

UTPAL KUMAR DUTTA¹, HAZRAT ALI², M. MAHFUJUL HAQUE², FRANCIS MURRAY¹, DAVID C. LITTLE¹, MD. ABDUL WAHAB³

1. Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland, UK; 2. Department of Aquaculture and 3. Department of Fisheries Management, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. Email: u.k.dutta@stir.ac.uk.

This work is part of the scoping phase for an EU-funded research project; Sustaining Ethical Aquaculture Trade (SEAT) assessing the sustainability of trade in four key farmed seafood species between Asia and Europe. This study was conducted using multiple PRA tools with emphasis on direct and key informant semi-structured interviews to assess the development and livelihood impacts of a recently established value chain node, the chatal, a primary auction market for shrimp and prawn. Chatals were disaggregated based on their relative remoteness, considering road conditions, travel times to urban centres and distance from processing plant. Chatals comprising multiple co-located auction houses emerged in the last decade as both shrimp and prawn production and farmers dissatisfaction with individual buying depots grew. The imposition of HACCP rules from the EU through Department of Fisheries (DoF) inspection wing Fisheries Inspection and Quality Control (FIQC) after 1997 was one of the main drivers to develop chatal. Producers found that the emergence of chatals has led to more competitive prices, fewer conflicts over weight estimates, instant cash transactions rather than credit and lower transportation costs. Less remote chatals tended to have better communication and infrastructure than remote markets and the price at less remote chatal tended to be 4% higher than remoter ones. Farmers themselves deliver shrimp and/or prawn to chatal directly; foria (market intermediaries) and depot personnel buy from the chatal; and supply to processing plants via commission agents. Farmers have to pay a 2-3% commission to arotder (auctioneer) as a service charge.

Sanitary condition at the less remote chatal premises was superior to the remote sites. This study found wide-ranging livelihood benefits to shrimp and prawn farmers in addition to a wide-range of other small-scale service-providers to these nodes.

Impact statement:

- i) As part of a scoping phase for the SEAT project, this work will contribute to the development of an Ethical Aquaculture Food Index (EAFI).
- ii) Hygiene and quality improvements for shrimp and prawn are potential areas for action research
- iii) Project outputs will help influence policy makers associated with seafood value chains

Key words: auction market (chatal), value chain, prawn and shrimp, farmers benefit, Livelihoods, Bangladesh.

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Value addition and environmental sustainability through efficient use of by-products and mortalities from aquaculture production in Europe and SE Asia

RICHARD NEWTON, TREVOR TELFER, DAVE LITTLE

Institute of Aquaculture, University of Stirling, FK9 4LA UK.

Email: richard.newton@stir.ac.uk.

The unprecedented growth of aquaculture in the last few decades has put increasing strain on world reduction fisheries and raised concerns over environmental impact issues and the general sustainability of this growth. Oversupply, increased costs and reduced profit margins have also made it increasingly difficult for producers to operate resulting in consolidation throughout the value-chain. It has therefore become increasingly important to increase resource efficiency and reduce waste within the industry for environmental benefits and for value addition. Post filleting by-products represents around 40%, 50% and 65% respectively for Atlantic salmon (*Salmo salar*), penaeid shrimp and striped catfish (*Pangasianodon hypophthalmus*) production, whereas mortality can be up to 30% in striped catfish production. The opportunities for their use in value addition have not been fully investigated however, and barriers are perceived to exist through Animal By-Product regulations (ABPR), lack of knowledge and logistics for their use. Secondary data from national production databases in Europe and Vietnam and stakeholder interviews in the Mekong region of Vietnam were used to ascertain the current situation of by-product and mortality use and the administrative structure that could facilitate cooperation and synergies between aquaculture and wider industry. A full review of technologies available for by-product and mortality use was undertaken that would be acceptable under the current European ABPR

and could be incorporated into the regulations or adopted in special circumstances. Results showed that the diffuse nature of Atlantic salmon processing in Europe would increase logistical difficulties for value addition compared to shrimp and catfish production in the Mekong region of Vietnam, although more technical barriers may exist for Vietnam. Many technologies of varying complexity were identified for value addition that could be used at varying scales and in conjunction with other industry depending upon the location and size of industry but more research would be required to understand the suitability of these technologies and the organisational structure that could facilitate the process.

Impact statement: It is expected that future research will lead to several example scenarios of eco-industrial clusters within European and Asian aquaculture where resources and by-products are used efficiently for economic and environmental benefits.

Key words: By-product, mortality, value-addition, sustainability, regulation, resource efficiency, eco-industrial networking.

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Description of the current striped catfish (*Pangasianodon hypophthalmus*) value chain in the Mekong Delta, Vietnam

LAM PHAN THANH¹, NHAN HUA THAI², HAI DAO MINH², HAI TRAN NGOC², PHUONG NGUYEN THANH², FRANCIS MURRAY³, DAVE LITTLE³

1. SEAT Project, Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland, UK; 2. College of Aquaculture and Fisheries, Can Thi University, Vietnam; 3. Institute of Aquaculture, University of Stirling. Email: lam.phanthanh@stir.ac.uk.

Catfish farming system in the Mekong Delta is one of the largest freshwater aquaculture industries in the world. This study describes the current value chain of striped catfish (*Pangasianodon hypophthalmus*) system in the Mekong Delta, Vietnam. The main objective was to determine value chain actors related to the catfish production and market systems. The survey was carried out at 6 provinces of which An Giang, Can Tho, Dong Thap and Vinh Long, are considered the most important areas of Vietnam in traditional models of production; and Ben Tre and Soc Trang provinces which are new development areas in the coastal zone.

The primary data was collected through structured checklists and questionnaires, stakeholder's visits and interviews. Specifically, a total of 55 grow-out, 25 hatcheries, 25 nurseries farms, 6 seed traders, 6 fisheries processing plants, 15 input suppliers, 5 feed-/chemical companies and other stakeholders were examined. The surveyed farms were randomly chosen based on a list provided by the respective administrations, and other stakeholders (labour groups for pond preparation or harvesting, chemical/drug shops, by-product traders, by-product processors, transportation services etc.) which were also

surveyed randomly at the same surveyed area. The results showed that there are many types of stakeholders who are involve directly and indirectly in catfish production and market systems. The farms, catfish processors and feed producers play an important role in the value chain of catfish system, while the rest are only support facilitators during production, harvesting, processing, distribution and export steps. The linkages among stakeholders such as between farmers and processors are too weak, thus the product competition on the market has decreased. An appropriate management measure, therefore, has been required to ensure catfish systems continue to develop in a sustainable manner. Strengthening of value chain linkages should be considered as a main priority activity in the next steps.

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Systems analysis of four export-orientated aquaculture value chains in China

WENBO ZHANG^{1,2}, LIPING LIU², HUANAN LIU³, FRANCIS J. MURRAY¹, DAVID C. LITTLE¹

1. *Institute of Aquaculture, University of Stirling, FK9 4LA UK*; 2. *College of Fisheries and Life Science, Shanghai Ocean University, Shanghai, China*; 3. *College of Economics and Management, Shanghai Ocean University, Shanghai, China. Email: wenbo.zhang@stir.ac.uk.*

China is the world's largest producer and exporter of seafood products and also the largest global producer of farmed seafood (FAO 2008). This paper reports research outcomes of the initial scoping phase of large-scale collaborative EU (FP7) project called Sustaining Ethical Aquaculture Trade (SEAT: 2009-2013). The project focused on four commodity species groups: tilapias, penaeid shrimp, *Macrobrachium* prawns and *Pangasius* catfish. The purpose of this scoping work was to: (i) clarify the status and trends for these value chains differentiating between domestic and export markets (ii) develop a sample frame to underpin site and species selection for focused follow-on research (iii) to begin to identify small and medium enterprises (SME) and their sustainability constraints for a future phase of action research.

Work resolved from secondary to primary data collection. Secondary data came from the FAO, National Bureau of Statistics of China, Agriculture Ministry of China and China Aquatic Products processing And Marketing Association etc. Primary data came from field surveys and key informant interviews using semi-structured interviews tools.

Mainland China accounts for 45% of world tilapia production (mainly *Oreochromis aureus* ♂ × *Oreochromis niloticus* ♀ and *O. niloticus* GIFT strain), and accounts for more than 77% of global tilapia exports (mainly to the US) (FAO 2008). China is also the largest global producer of penaeid shrimp (mainly *P. vannamei*, *P. chinensis*, *P. monodon* and *P. japonicus*) and *Macrobrachium* prawns (mainly *M. rosenbergii* and *M. nipponense*). China is the

second largest exporter after Thailand in volume and third largest exporter after Thailand and Vietnam in value of shrimp and prawns (FAO 2008).

Tilapia and shrimp were identified as strong candidates for follow-on research in Hainan and Guandong Provinces. *Macrobrachium* prawns are mainly produced for domestic market, and *Pangasius* catfish is not produced in significant quantities in China.

Export licensing rules effectively closed export markets to smaller producers. There has been marked consolidation in export-orientated value chains. Farmers identified key sustainability concerns emphasising low margins for tilapia production and diseases for shrimp. Earlier food safety related bans were identified as reasons for limited export of these products to the EU.

Impact Statement: This work will help to: 1) make the four export-orientated aquaculture value chains more transparent; 2) improve seafood trade linkages between EU and China, 3) find the main factors restricting development of the four export-orientated aquaculture value chains, 4) provide advice to policy makers 5) select appropriate sites for the next stage of research.

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Impact of extension services on inland aquaculture development for poverty eradication in the north west regions of Namibia

PANDULENI N. ELAGO AND MD. GHULAM KIBRIA

1. Chief Fisheries Biologist, Omahenene Inland Aquaculture Centre (OIAC), Head of North West Region, MFMR-Namibia; Email: panduleni@jway.na; 2. Aquaculture Advisor, Commonwealth/ MFMR-Namibia; Email: kibriamg@mfmr.gov.na

The Government of Namibia gives priority on food security and poverty reduction through developing various components of rural sectors including fisheries and aquaculture. The country has magnificent potential for the development of aquaculture. It was estimated that only one third of the available water area are currently in use for aquaculture purposes. In order to support the freshwater fish culture development in the north western part of the country, an Inland Aquaculture Centre (IAC) was established in 2003 under a Project called 'IAC Project', fully funded by the Government of Spain, with an agreement that was reached in 2003. The Ministry of Fisheries and Marine Resources (MFMR) was a part of the management of the project, with the major responsibility of developing suitable freshwater aquaculture technologies including fish breeding, seed production, training and extension to meet the domestic requirements. Support was extended by the Spanish Agency for International Cooperation (AECI) and MFMR to this sub-sector through a technical assistance project "Aquaculture in Northern Namibia (ANN)" since April 2007 and continued until February 2009.

One of the main objectives of the ANN project was to strengthen extension services through small scale rural aquaculture support. The project enhanced the capacity building of Oshakati Extension office and fish farmers. A total of 700 registered small-scale fish farmers were included at the Inland Aquaculture Extension Services office under the ANN project. It was found at the end of the project, that about 50 fish farmers were actively involved in this community-based fish farming operation. Strengthening of extension services remains limited. Although the project improved on the upper level of fish farming, much was left unanswered to the grassroots farmers in terms of realising the social and economic impact which this project was supposed to bring in for the development of Aquaculture in Namibia. The current environmental and climate conditions in the country contribute to the fluctuations in response and participation of potential farmers willing to be part of the process. It is being increasingly felt that that most farmers need necessary financial help or important supporting services. These needs still require to be evaluated. However, the latter refers to the question - can fish farming in the North West be income related and can it derive food for all with a view to ensure poverty reduction. Therefore, further Interventions need to be directed not to the government but to the individual potential community and private initiatives.

There are lessons learned from the ANN project. Some of those have really put forward some genuine questions as to what coverage needs to be considered for aquaculture intervention in the North West region; and what next should be considered for attaining greater achievements by the government in the near future.



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