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Cobia hatchery technology

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Lymphocystis disease





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NACA
An intergovernmental organization that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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A new member of NACA: Welcome Indonesia

I am pleased to announce that we have a new member in the NACA family: The Government of the Republic of Indonesia acceded to the NACA Agreement upon signature of the President this quarter. As regular readers will no doubt be aware, Indonesia has a long history of being actively involved in, and providing support to, NACA activities right from the networks' first days as an FAO project.

The Government of Indonesia was a participant in the FAO/UNDP Regional Project to Establish the Network of Aquaculture Centres in Asia-Pacific (1980-89), as well as in the Regional Seafarming Development Project (also of UNDP/FAO, 1987-91) managed by NACA. When NACA became an autonomous intergovernmental organization on 1 January 1990 the Government of Indonesia was actively involved in the formulation of the NACA Agreement and the activities that prepared it for independence, including adopting the Agreement at the Meeting of Plenipotentiaries convened by FAO in Bangkok in January 1988, and developing its initial work program and funding mechanism.

As a member government of the NACA Project, Indonesia designated its Brackishwater Aquaculture Development Centre in Jepara and Freshwater Development Centre in Sukabumi as National Aquaculture Centres. The Seafarming Development Centre in Lampung was designated as the nodal center of the regional seafarming development project; it became a NACA seafarming center when the network became autonomous.

Throughout the years, Indonesia has participated in many other flagship NACA projects and programmes, including:

- The Senior Aquaculturists Training Course (M.Sc.) offered between 1981-1989, which trained many scientists and policy makers that went on to take up leading positions in research institutions and government;
- The Regional Fish Disease Control and Fish Health Management Study and Workshop (1989-90), a landmark study, which focused governments' attention on the importance of strengthening fish health management capabilities;
- The Aquaculture Sustainability and the Environment (1994-96) project, funded by the Asian Development Bank, which evolved an Aquaculture Sustainability Action Plan addressed to international/regional organizations, governments, farmers and farmer-support institutions;

In more recent years Indonesia has played a key role in the Asia-Pacific Marine Finfish Aquaculture Network, leading the way with ground-breaking research and sharing its expertise through activities such as the Regional Grouper Hatchery Production Training Course. NACA members have in turn shared their expertise and support to Indonesia, notably in the determination of and response to the Koi Herpes Virus outbreak that seriously impacted carp production, and in the recovery from the tsunami disaster of December 2004.

This is just a small sample of Indonesia's involvement in NACA. We look forward to officially welcoming Indonesia as the 17th member government of NACA at the Governing Council Meeting in Iran in February, and to continued strong collaboration between Indonesia and all NACA members in the years ahead.

Simon Wilkinson

AQUACULTURE ASIA

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Notes from the Publisher

Technical cooperation between developing countries works

This is the second part of a series on NACA's history, development and experiences. The preceding issue described the Network's passage from a regional project to an independent organization and the preparations done and efforts made towards stability. This installment relates the period during which NACA firmly demonstrated that technical cooperation among developing countries does work and moved it, in the words of Chen Foo Yan, the coordinator from 1980-89 and the acting coordinator in 1990-91, "from the realm of lip service to reality."

The core of the cooperation is provided by the Regional Work Programme, a rolling plan divided into five-year periods. It is formulated by governments reflecting their common objectives and interests, and developed by a wide collaboration among stakeholders and partners.

As an intergovernmental organization, cooperation among members underpins NACA's operation. Such cooperation facilitates the exchange of known technology, exchange of scientific findings, dissemination of new knowledge and information, and exchange of expertise. Networking makes the above activities economical and effective: there is no duplication from lack of communications, participating institutions and experts build on and add value to each others' work, they can work together to solve a common problem, and the strengths of each and every institution are brought to bear on addressing common issues. By doing things in different ways they complement one another's efforts. They also reach groups they would not normally work with directly. Such cooperative work also contributes to strengthening the capacities of every participant, and therefore of the whole network. The new information and communications

technology (ICT) tools greatly facilitate networking although they may not necessarily enhance cooperation.

This section describes a number of useful lessons from NACA, as a networking arrangement:

1. Technical cooperation works

Sharing resources and responsibilities among institutions (and countries) through networking is probably the only practical and cost-effective means available for solving the diverse problems faced by aquaculture due to the diversity of species, farming systems, and environments, and varying levels of development among countries. The networking (and sharing) approach is also in line with governments' objectives of regional self-reliance through technical cooperation. Cooperation becomes more compelling in the face of limited resources of governments and donors, and the need to best utilize internal resources and external support. The complex and many challenges faced in the development of aquaculture, a relatively new economic activity, also argue for a collaborative approach to make efficient use of resources to solve problems. Adding a very important dimension to cooperation, the NACA members have committed to the principle that the stronger members shall assist the others.

2. Ownership and continuity of initiatives

Programs and projects are developed so that they address the priority issues and needs expressed by members (governments). These expressed needs and priorities are translated and formulated into a regional action plan (by the Technical Advisory Committee of NACA),



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which is adopted into the regional Work Program – a rolling Five-Year Plan – by the Governing Council. Three attributes of the NACA work program emerge from this arrangement; the program is: (i) owned by members; (ii) a product of consultations among the various stakeholders, and (iii) implemented by the members themselves in a cooperative and coordinated way that builds on the capacities in the countries and complement those of the regional institutions.

These attributes make two important conditions happen: (i) governments commit resources to implement the programs, and (ii) governments and interested institutions in the respective countries take up the results in their policy and programs, assuring continuity of the various initiatives, rather than being terminated when the project ends.

Another significant point is that the regional program is based on common needs and priorities of the members, not on the overriding interests of one or two.

3. Strategy for capacity building of the Network

When NACA evolved from a UNDP/FAO Project to an independent intergovernmental body (in 1990 after 9 years as a regional project), it adopted a major change in operational strategy. It had to: (i) become self-sustaining in order to finance core activities (such as technical advice, information exchange, and overall network activities coordination and secretariat administration),

(ii) generate revenues by provision of services against payments, (iii) develop programs and projects for collaborative assistance of donors and development agencies, and (iv) enter into partnerships with other institutions and work with them on areas of common interest.

Partnership and collaboration becomes mutually beneficial if the independence of the organization is maintained. In practical terms, NACA's programs should be developed and owned by the members and not imposed upon or influenced by external agencies; it has the basic organizational capacity and resources to operate the programs; and the interest of donors should match the priorities of the organization, not the other way around.

4. Demonstrating results

The overall strategy in project implementation was to: (i) increase aquaculture production through effective transfer of proven technologies in the region; (ii) train senior personnel in the planning and management of aquaculture development and production projects; (iii) help justify government financial support to national aquaculture projects; and (iv) take on only relevant adaptive research that facilitates increasing production, leaving basic research to complementary activities from academic institutions.

Priority was thus given to producing early visible and measurable results for increasing aquaculture production in the region. This was aimed to assert the economic and social importance of aquaculture for the attention of development policy planners in governments. This was achieved by effective transfer of established viable, commercial technologies and techniques through applied and adaptive research in both host and recipient countries. The trials of established aquaculture production systems adapted them to local conditions. Through the cooperation among the centers, technical and managerial details of established aquaculture production practices were systematically transferred by way of training courses, workshops and seminars, as well as specialized technical assistance (i.e. expert exchange) and via information dissemination.

5. Providing the science to traditional production practices

In Asia, established aquaculture production technologies have a long history. They were evolved through traditional trial-and-error practices. Research was then disciplinary or very specifically problem-focused rather than systems-oriented. NACA thus emphasized research that would promote scientific understanding of vital inter-relationships of salient dependent and independent variables for the improvement of production systems of importance to the region. As an example, the age-old highly productive integrated fish farming systems in China – evolved through many centuries into an art by Chinese farmers – were studied and given scientific basis. As such, the technology was provided scientific explanation and therefore transferred more easily throughout the region through workshops, training, information and extension. It then also became susceptible to further scientific improvement.

Three conclusions on the benefits from a regional networking arrangement (of governments) emerge from the above discussion:

1. From the point of view of results, a broad-based collaboration on specific programs that involve numerous institutions can multiply benefits to the institutions themselves, to governments and to the people in the aquaculture industry. Cooperation in areas of mutual interests – through specific programs or projects – can effectively muster resources, expertise and institutional support to implement regional projects, promoting synergy, avoiding duplication of activities, and expanding the range of beneficiaries. NACA has generated support for the implementation of major regional and national activities from bilateral, multilateral and investment agencies.
2. From the capacity building perspective, training of national personnel and upgrading of facilities have created a multiplier effect for various assistance programs. The improvements that NACA brought about on regional and national capacities (that include trained people, more

efficient operating and management systems, and upgraded facilities) have attracted and made it easier for donor assistance programs to be effectively implemented. The multiplier effects include (a) wider dissemination of results, (b) assurance of follow-up activities within governments thus ensuring continuity of project-initiated activities in the NACA program of work, and (c) utilization of strengthened national institutions by various assistance programs.

3. Cooperation and commitment are the basic forces that move the organization.

Announcement

The Second International Symposium on Cage Aquaculture in Asia

3-8 July 2006, Zhejiang University Hangzhou, Zhejiang Province, China.

The first cage culture symposium was successfully held more than five years ago and the aquaculture community will be meeting again in Hangzhou city, China to discuss the recent advances, potentials, challenges and problems of cage aquaculture in Asia.

The second international symposium on cage aquaculture in Asia (CAA2) scheduled for 3-8 July 2006 will discuss the following topics:

- Recent advances and innovations in cage culture technologies.
- Cage design, structure and materials
- Site and species selection.
- Nutrition, feed, feeding technologies and management.
- Disease prevention and health management.
- Economics and marketing.
- Sustainable management and development.
- Policy and regulation.
- Constraints to cage culture development.
- Conflicts between cage culture and other stakeholders.

For more information, contact: Secretariat, 2nd International Symposium on Cage Aquaculture in Asia
Tel. and Fax +86-571-86971960,
Email: CAA2@zju.edu.cn.

Peter Edwards writes on

Rural Aquaculture

Small-scale pond culture in Bangladesh



A large number of beneficiaries from aquaculture.

In my previous column, "Asia Development Bank study on Aquaculture and Poverty" (Aquaculture Asia Vol. X, No. 3, pages 6-8), I outlined a recent study to assess channels of effects of aquaculture to generate livelihoods and reduce poverty. Here I present more details of a case study from the ADB study of small-scale fish farmers in Kishoreganj in the Greater Mymensingh Area (GMA), which is the major area for freshwater aquaculture in Bangladesh.

Freshwater aquaculture, primarily through farming of carps, plays an important role in rural livelihoods in Bangladesh. It provides employment and income as well as accounting for 60-80% of the animal protein consumed by the population and is a major source of essential vitamins, minerals and fatty acids. Freshwater aquaculture provides more than a third of the total fisheries production in the country.

Over the last decade there has been a dramatic increase in freshwater aquaculture production, from 124,000 t in 1986 to 561,000 t in 2000, with average yields increasing from 0.84 to 2.44 t/ha.

Kishoreganj was one of 22 districts targeted by the Department of Fisheries (DOF) from 1988 to 1997 under the ADB-financed Second Aquaculture Development Project for the dissemination of improved fish culture practices using semi-intensive rather than traditional extensive carp polyculture technology. The province also benefited from the DANIDA-financed Mymensingh Aquaculture Extension Project from 1989 to 2003 as well as various development projects funded by the Government, bilateral agencies and multilateral organizations in collaboration with the DOF.

The ADB case study was based in part on a survey of 100 fish farming households who owned individu-

ally managed ponds. The household respondents were selected from three upazilas typical of the GMA but where there had not been intensive extension support. To avoid any significant bias due to direct assistance, the respondents were selected from those who had not been appointed by DOF as demonstration farmers or as extension contact agents.

There was an abundant carp seed supply, as is the case in many parts of Bangladesh, from a large number of hatcheries. Carp seed prices have declined in recent years. Nursing of fry to fingerlings is commonly carried out by household-level small-scale nurseries in villages, providing employment to owners and hired labour. Travelling seed traders carry a few thousand fingerlings each in aluminium containers on foot or bicycle.

Traditionally, much of the farmed fish came from ponds constructed as borrow pits, dug to raise the level of land for village homesteads and roads on the flood plain. With the growing importance of freshwater aquaculture, ditches that were formerly only flooded seasonally have been converted into perennial ponds through deepening and expansion in area.

Among the 100 fish farming household respondents, 98% farmed a carp polyculture of up to nine fish species. Over 80% of respondents stocked fingerlings of at least 5-7 cm, and 25% of these stocked fingerlings of at least 8-10 cm. Among respondents, 98% used pond fertilizers (mainly cow manure and urea but some used poultry



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manure and triple superphosphate) and 99% used supplementary feed (mainly rice bran and oil cake but some used banana leaves and grass). Over 90% harvested fish more than once per year, almost half using hired local labourers specialized in providing harvesting services. Almost half of respondents either drained or dried their ponds on occasions.

It came as no surprise that the productivity of the fishponds was high because of the relatively sophisticated, semi-intensive aquaculture practice. The average extrapolated annual fish pond yield in this study was 3.1 t/ha, only a little lower than that of households in ponds in the GMA, 3.3 t/ha, whose owners received direct support from the DANIDA-funded Mymensingh Aquaculture Extension Project.

Small-scale farming households benefited from both sales and consumption of fish. All respondents sold fish (an average of 244 kg) and 99% of respondents consumed fish (an average of 56 kg). In 2002 each household received an average farm gate price of Tk.39/kg, a gross revenue of Tk.9,500 and a net income of Tk.5,400 from fish farming (US\$ 1 = Tk. 58 approximately). The marketing chain for fish was short with most farmers selling their fish locally, either in their own village or at a nearby upazila market. Most farmers did not sell directly to consumers but dealt with market intermediaries, further generating employment.

Households had only moderate experience in fish farming with over 50% of respondents reporting no more than 3-5 years of experience. All surveyed farmers reported that their current fish farming practices originated locally; and 90% of them claimed that they had acquired information on fish farming from other farmers and 40% from friends and neighbours. As respondents were purposefully selected from upazilas where there had not been intensive extension support, and farmers who had not been appointed by DOF as demonstration farmers or extension contact agents, the major source of information dissemination was farmer-to-farmer. The requisite fish farming technology had been introduced into the area initially through projects but diffusion of feasible and relatively simple, low-cost



A typical fish pond.

technology readily occurred through farmer-to-farmer contact. The farmers clearly had benefited from aquaculture as 55% of respondents indicated a willingness to pay a modest amount of cash, or in kind as a portion of the harvest, for good extension advice if it would significantly increase their fish harvest. Thus, privatisation of extension services appears to be a feasible strategy to reach a large number of farmers and potential new entrant farmers in aquaculture in the area.

Most of the respondents (69%) reported that they had relied on their own financial resources for operating fish

ponds. It would thus seem that lack of credit may not hinder small-scale farmers to stock ponds with fingerlings, particularly when much of the fertilizer and supplementary feed can be obtained from on or around the farm.

In the context of rural Bangladesh, fishpond owners may be generally categorized as relatively better-off among rural households. However, they do not necessarily escape from poverty. Among small landowners in Bangladesh with moderate access to land of 0.5-1 ha, including fish ponds, 34% live below the poverty line. They do not produce much surplus from farm-



An itinerant seed trader.



A fish harvesting team at work.

ing and are vulnerable to crises. Even some fishpond owners who may be categorized as medium-size landowners with 1-2 ha of land are also vulnerable, and 25% of them live below the poverty line with the rest precariously above it. They can easily slide into poverty when faced with an unexpected crisis. A large majority of the respondents in the study were exposed to several crises, the most serious being illness of household members, shortage of food and damage due to floods, erosion, heavy rain and cyclones.

The respondents were optimistic about the benefits of fish farming. Compared to 5 years ago, the surveyed households overwhelmingly confirmed that :

- their food and fish consumption had increased;
- they had benefited from employment and cash income;
- conditions of natural resources for fish farming had not declined;
- access to aquaculture technology had improved; and
- adoption of fish farming technology had increased.

The respondents were also optimistic about their future in fish farming and anticipated that they would continue to benefit from aquaculture. A large majority (90%) of respondents would continue to farm fish while the rest were undecided. The minority who were undecided about continuing to farm fish reported various reasons such as potential conflicts related to multiple pond ownership, inadequate knowledge, low profitability, and insufficient time for fish farming.

The study on which this column is based is available on the ADB web site and as a printed book with the title "An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction:

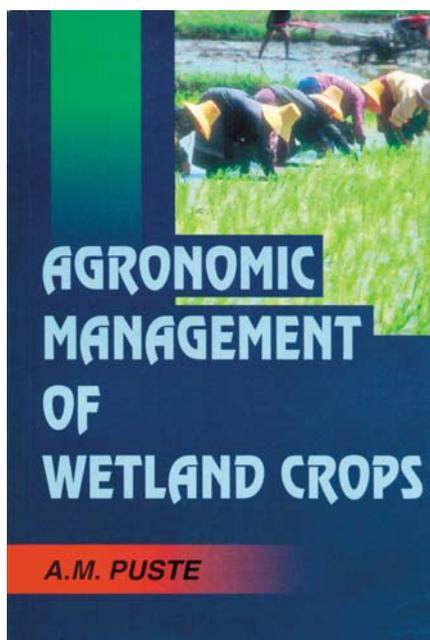
<http://www.adb.org/Documents/Reports/Evaluation/sst-reg-2004-07/default.asp?p=opereval>.

Also listed at oneFish:

<http://www.onefish.org/servlet/CDSServlet?status=ND04MTU1MS4yNDk2MDomNj1lbiYzMzlkbn2N1bWVudHMmMzc9aW5mbw~#koinfo>.

For a hard copy contact: Njoman George Bestari, Senior Evaluation Specialist, Operations Evaluation Department, Asian Development Bank, Email: nbestari@adb.org, Tel: (632) 632-5690, Fax: (632) 636-2161.

Agronomic Management of Wetland Crops



The productive potential of wetlands has received little attention despite the abundance of such areas in Asian countries, which is comparable in area to arable croplands. Wetlands, whether they are permanent or ephemeral in nature, have significant potential to produce aquatic crops including fish for food and ornamental purposes, fodder crops, medicinal and aromatic plants. *Agronomic Management of Wetland Crops* seeks to redress this issue by providing guidance on selection and cultivation and utility of wetland crops, with reference to soil and water characteristics.

The book begins with an introductory section that describes the general features of wetlands including their characteristics, importance, classifica-

tion (including of coastal wetlands), water quality and some of the common problems they face from a common public perception of being 'marginal' lands. The second section of the book contains seven chapters devoted to wetland crops, including aquatic food crops, ornamental plants, non-food commercial crops, fodder crops, medicinal leafy vegetables, aromatic plants and aquatic weeds. The book is 315 pages in length and includes around 100 photographs.

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Community based aquaculture - issues and challenges

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In many parts of the world capture fisheries are under pressure or in crisis. Many of the management problems in fisheries have been attributed to the remoteness of government from the people and the activities it wishes to regulate. Fisheries management is not so much about managing fish, it's all about managing the way people and fishers capture fish and affect their environment. With India's population increasing and expected to touch 1.33 billion by 2020, the demand for fish is growing. However, because of the shift in consumption pattern as a consequence of economic development, the demand for food fish is also on the increase. When supply cannot cope with demand, price rises and it is the poor who find fish disappearing from their food basket¹.

Participatory fisheries management

Participatory fisheries management is an innovative approach to decentralize management authority and make the fishermen resource managers². The idea of resource users as resource managers makes sense because it is in their interest to ensure that the long-term productivity, stability, sustainability, equity, bio-diversity of the fisheries resource are looked after. Many fishermen feel that government intervention in fisheries has lacked commitment and sustained effort, with many fisheries policies and assistance programmes lacking consistency and continuity.

Fisheries management has traditionally been carried out in a very impersonal kind of way. The old 'custodian' fisheries management system, developed and followed over a hundred years, were rendered ineffective in the fifties and sixties due to various reasons. The time has come for governments to recognize the rights and concessions of the people eking out a living from the fisheries resources; the emphasis on direct financial gain must

also be subordinated to environmental sustainability; and the people must be involved and take some responsibility in the management of the resource. For these things to happen, the people who have often been considered as unauthorized intruders and denied access to fishery resources, must be accepted as partners in the process of development.

Community based aquaculture management, based on the principles of participation, is receiving increased attention. In Orissa, several fish farming groups have been organized and given lease of community tanks for productive use. It is often argued that community based management of fisheries often delivers better results than 'traditional' government based management. However, quantitative data in support of such assertions are difficult to find. We have made an attempt to evaluate the performance of community-based aquaculture in qualitative terms. Factors responsible for the success or failure of community-based aquaculture have also been identified.

The study

The study was undertaken in Puri District of Orissa and in Purulia District of West Bengal. We adopted a case study approach where in-depth data was collected from both successful and not so successful community based aquaculture systems. We conducted focus group interviews of 70 members of such groups to elicit the reasons for success or failure of such community initiatives.

Constraints

We identified a range of important constraints based on discussion with the experts in related fields and through review of relevant literature. We presented the list of constraints to the respondents, who were asked to rank each against a three-point scale of severity; a score of three indicated

a strong constraint; two indicated a neutral reaction or no opinion; and one a weak constraint. Constraints were ranked based on the mean score obtained and are discussed below, in order of the perceived severity by respondents.

1. Conflict in distribution of benefit

Inequitable distribution of benefits was cited as the most severe constraint to the development of community based aquaculture by 80% of the respondents. There are some members who rarely take part in any of the activity, and whose participation is rather passive in nature. Though efforts are being made by the Panchayet (village committees) a lot of improvement is required. Sharing of benefit equally among the members may create bitterness in such instances; in other words respondents felt that the relative efforts of participants should be a factor that is considered in the distribution of benefits.

2. Dominance of individuals

The second important constraint identified by the respondents was dominance of community-based aquaculture by particular individuals, for example during the conduct of meetings. True participation may not occur unless the views of each member are respected. In Puri District we observed that only one or two members would actively speak at a meeting and the others simply attend and agree to whatever he or she says.

3. Absence of community love, sense of mutual cooperation

An honest and respected local leader can foster community love and derive commitment for mutual support. The absence of such a leader can be an important constraint to community based aquaculture management, which cannot

Table 1. Constraints to community based aquaculture (n=70)

Constraint	Mean score	Rank
Conflict on distribution of produce/benefits	77.7	1
Domination of individuals in the whole affair	73.7	2
Absence of community love, sense of mutual cooperation	71.1	3
Conflict on right to catch small assorted fish	55.5	4
Poor technical skill of farmers	48.8	5
Failure of executive committee to protect the interest of the members	46.6	6
Market intermediaries	44.4	7

succeed without the willing support and cooperation of all members. Seventy one percent of the respondents felt that there is need for more commitment and involvement of all participants in achieving the common goal.

4. Right to catch small, assorted fish

Fringe dwellers, who used to look at community water bodies as common resources, continue to catch fish as if it is their right to do so. Self-help groups that had obtained a lease to cultivate water bodies felt that this was detrimental to fish production. In a few cases in Orissa as well as in West Bengal the conflict had led to closure of the community based aquaculture management activity and the water body lay unproductive. This is the fourth important constraint in descending order of severity. Some community based aquaculture groups enacted their own restrictions on the kind of nets that could be used by fringe dwellers and implemented checks to ensure that high value fishes were not being caught.

5. Poor technical skill of farmers

Technical knowledge and skill of fish farmers was found to be poor. Future technologies are going to be knowledge and skill intensive. Surveys indicated that the majority of fish farmers follow age-old practices and as a consequence they get a very low yield (sometimes below 1 ton/ha/yr.). Farmers also lack expertise in dealing with disease and mortality. McNeil² emphasized technical competency to bring about the adoption of new knowledge and skill. Informal education, group discussions, community video and method dem-

onstrations would help reinforcing the skills needed to improve production.

6. Failure of executive committee to protect the interest of the members

Respondents reported that executive committee members who are supposed to protect the interest of members have at times failed to do so. Though it was not ranked as a significant constraint by respondents, some community based aquaculture management activities ceased to function owing to such failures. The siphoning of benefits by a few members for their own personal gratification was an issue reported by 47% of the respondents.

7. Market intermediaries

Disposal of fish at poses a great problem at times. In our survey 44 % of the respondents indicated that this was a constraint. In the absence of organised marketing farmers have two options - (i) take it to nearby market and wait for the customer or (ii) sell it to a middleman at a much lower price. Quite often the farmers resort to the second option and as a consequence get a poor price.

Conclusion

The past decade has witnessed an enormous expansion in the potential scope of fisheries in developing countries. This change is an expression of essentially two interrelated factors – (i) a broad movement towards increased participation of local people in development and (ii) recognition of fisheries as a weapon to fight poverty and malnutrition. If sustainable aquaculture management is to occur, the movement must be broad based involving a broad range

of stakeholders. Fishermen, NGOs, line departments, research institutes all hold part of the answer.

While participatory management of water bodies for culture based fisheries are being promoted it should not be presumed that this will in itself lead to equitable distribution within the local population. Community based aquaculture has many advantages and may be used as an alternative to conventional centralized fisheries management systems. Community based aquaculture has the potential to allow all stakeholders a greater participation in the decision making process, hence it creates a more transparent management system. It will also improve compliance because stakeholders will develop a feeling of ownership concerning all decisions. A more effective fisheries management will result, as stakeholders will be more inclined to voluntarily comply with rules that they had themselves agreed to.

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Aquaculture as an action programme: An exercise in building confidence and self worth

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The ageing of the population is one of the biggest challenges facing present day social policy makers. There will be nearly 100 million people of pensionable age, with the steepest increase among those of 80 or more, whose numbers are set to quadruple between 1960 and 2020¹.

It is important that the senior citizens of the developing countries are also given the opportunities to develop social and economic skills that will sustain their interest for life and values of life. It is equally important that they also get involved in social activities that will help them to keep physically and mentally occupied.

Beliefs about desirable levels of activity in older people need to be changed. Despite the natural effects of ageing, including diminishing capabilities, chronic diseases and handicaps, we now have the knowledge, the technology and the skills to prolong personal independence and a reasonable quality of life².

Action will be needed to relieve physical symptoms and address fears about perceived ability to undertake physical activity³. Various forms of economic activities have been suggested to keep people in the senior citizen age group productively occupied. Gardening, carpentry, small-scale floriculture and masonry are some of the activities that have been promoted for engaging people in this age group productively.

The emerging multi-disciplinary field described as ‘ageing and technology’ sets out to prevent or compensate for declining abilities or age-related problems, improve the quality of life for older people and assist their careers, and acquire a better understanding of the ageing process⁴.

Medical experts have come up with specific programmes for older people to live healthier and longer lives, such as doing exercise or other things they



Residents of the home.

wanted to do. No, researchers have found an easier way: people 65 years and older can extend their lives by doing things that are easy and enjoyable².

The Central Institute of Brackish-water Aquaculture (CIBA) has been active in research and development and transfer of such technologies through practical demonstrations. These efforts have been focused towards the disadvantaged sections of the population also. The institute has come out with a number of technologies that have great relevance for conducting programmes to build confidence and self-worth among the not-so-privileged sections of society.

This article deals with one such demonstration programme, in which small-scale backyard aqua farming can be advocated as a productive hobby for senior citizens.

The demonstration site

A home for the aged known as “Anbagam” (House of Love) is being run by the Church of South India, Adyar,

Chennai. The home was started in 1968 and was established in 1969 in the present permanent premise. There are 42 inhabitants living in Anbagam. The home provides a good ambience for aged people and provides proper care in terms of food, shelter and clothing. The home has a small man-made pond of approximately 0.033 hectares, being around 25 metres long and around 16 metres wide and 75cm deep. The water level is maintained by daily pumping to compensate for seepage and evaporation.

The water and soil of the pond were tested and deemed to be suitable for brackishwater aquaculture, so culture of brackishwater fishes was trialled with technical support from CIBA. Experts from CIBA visited and surveyed the pond, and suggested the possibilities and process of culturing suitable brackishwater species of fish and shrimp.



Anbagam demonstration pond.

Seed stocking

Milkfish (*Chanos chanos*) seed of 15-70mm size, collected from the wild, were stocked at the rate of 8,000/ha along with tiger shrimp *Penaeus monodon* seed (PL 12) procured from a local shrimp hatchery, at 70,000/ha. The pond was stocked in May, with the intent to carry out polyculture.

Water quality in the pond

The pond water quality parameters were monitored at frequent intervals. Water samples were collected every month and analysed for temperature, pH, salinity, hardness, alkalinity, total ammoniacal nitrogen, nitrite nitrogen and dissolved oxygen (table 1).

During the culture period, salinity, pH and temperature ranged between 8-10ppt, 7.1-9.1 and 29-33°C. Dissolved oxygen content, total ammonia and nitrite nitrogen concentrations were within permissible levels over the entire culture period.

Pond soil analysis revealed that the soil pH decreased from 8.12 to 7.89 and the organic carbon content increased from 0.78 to 9.96% at harvest time, indicating the accumulation of organic matter on the pond bottom (table 2).

Feeding

Conventional fish feed containing rice brand and oil seed cake mixture was given to milk fish twice daily at the rate of 3% of body weight, at 9am and

6pm. The feed ratio increased gradually as the fish and shrimp gained weight. CIBA starter feed was provided in the initial phase for 30 days for the tiger shrimp followed by grower feed for the next 30 days and finisher feed up to 40 days. A check tray was used to monitor feed consumption.

Shrimp and fish production

The harvesting was carried out with cast nets and by hand picking. The milk fish attained an average size of 265mm (range 230-300mm) and 275g weight (range 250-300g) in 130 days, and the total yield of milkfish was around 40kg.

The survival rate was around 92% for milkfish and 20% for shrimp. The shrimp and fish production was

equivalent to 330kg/ha and 1,212kg/ha respectively.

Economic analysis of polyculture trial carried out in Anbagam

The results of the economic analysis done of the data obtained from the trial conducted in Anbagam pond are presented in table 3. This analysis consists of two parts: Actual data from the present trial is in part A. This includes the items given free of cost to the participants. In part B, the same data is analysed taking market value as the cost of items for the free items listed in the trial. The general assumptions made are kept common for both scenarios. It is clear from the analysis presented that both enterprises are viable activities for the inhabitants of Anbagam.

The gross return was Rs. 2000 from shrimp and Rs 1200 from milk fish. The net return realised from shrimp was Rs. 1520 and from milkfish Rs 575. In the given situation of inhabitants carrying out the culture without aid, the activity is still viable with a net return of Rs. 775 for shrimp and Rs. 191 from milk fish. The undiscounted benefit:cost ration of 1.63 and 1.19 for shrimp and milk fish is acceptable.

The income could be further improved if the survival of the stock could be maintained at 60%. This is reflected by the sensitivity analysis done with the data presented above showing that the net return could be increased to Rs. 3,805 from tiger shrimp alone if the survival rate could be improved to



Cast net catch of milk fish and tiger shrimp.

60%. In this sum, the activity is a viable livelihood option for the inhabitants of Anbagam.

Confidence building and self-worth

The ultimate objective of the trial was not just to demonstrate the economic viability of the activity, but to demonstrate the positive social benefits and improved quality of life that accrued to the elderly people of Anbagam through their participation. Any extension exercise in terms of an action programme needs to be monitored not only in terms of physical output generated by the experiment, but also in terms of the participation of the people. In this trial, all 42 of the elderly people living in Anbagam actively participated in the fish farming project during the entire culture period. We noted that people assisted each other and enthusiastically identified themselves with the farming activity. The participants themselves indicated that they felt an overall improvement in their physical and mental well-being during the course of the work, partly due to a degree of physical activity but also from a sense of involvement.

The aged people engaged themselves in monitoring pond water depth, supplementing the water pumping operations, feeding, netting and related activities. The whole programme enabled them to improve the quality of time that they spend in their daily life. The trial also offered them an opportunity to affirm their self-worth by increasing their income through the sale of fish and shrimp produced from the backyard pond of their home.

Acknowledgement

The authors are thankful to Dr. P. Ravichandran, Director of CIBA, for his guidance and encouragement. The authors are also thankful to Dr Mathew Abraham, Dr. A.R. Thirunavukarasu, Dr. S.M. Pillai, Dr. N. Kalaimani, Dr. S.A. Ali, Dr. B.P. Gupta, Principal Scientists, for their active participation and periodic review of the farm operations.



Harvested shrimp.



Harvested milk fish.



Scientists and residents of the house with the shrimp and fish they have harvested from their backyard pond.

Table 1. Water quality parameters during the trials.

Month	Temp.	pH	Salinity (ppt)	Hardness (ppm)	Alkalinity (ppm)	Total ammonia nitrogen	Nitrite N (ppm)	Dissolved oxygen (ppm)
June	30-32	7.1-8.2	8-10	1087.5	97	0.177	0.234	8.0
July	29-30	7.2-8.0	8-10	1248	95	0.416	0.18	14.9
August	32-33	7.2-8.1	8-10	1186	99	0.495	0.218	7.4
September	29-30	7.2-8.3	8-10	1309	102	0.546	0.284	7.9

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4. OCECD (2000a). "How will ageing affect Finland?". OECD Economic Surveys, Finland. Paris.

Table 2. Pond soil analyses during the trials.

Month	PH	E.C. (ds/μ)	Organic carbon %
June	8.12	2.8	0.78
July	8.04	3.0	0.84
August	8.10	3.1	0.92
September	7.89	3.1	0.96

Table 3. Economic analysis of the trial outcomes.

Assumptions	Tiger shrimp			Milkfish		
Area	0.033ha			0.033ha		
Stocking rate/ha	70,000			8,000		
Survival rate	20%			92%		
Average harvest weight	25g			275g		
Price/kg	Rs. 200			Rs. 30		
Costs/return operating costs	Quantity	Value	Total	Quantity	Value	Total
Fry	2,000	Free	Free	265	Free	Free
Feed	1.5	Free	Free	60	Free	Free
Power	-	-	480	-	-	625
Total operating costs	-	-	480	-	-	625
Gross return	10	200	2,000	40	30	1,200
Net return	-	-	1,520	-	-	575
Without aid						
Fry	2,000	0.35	700	265	0.75	198.75
Feed	1.5	30	45			185
Power	0	0	480	0	0	625
Total operating costs	-	-	1,225	-	-	1,008.75
Gross return	10	200	2,000	40	30	1,200
Net return			775			191.25
Undiscounted benefit:cost ratio			1.63			1.19
Sensitivity analysis with 60% survival						
Gross return	30	200	6,000			
Total operating costs + increased feed			2,195			
Net return			3,805			
Undiscounted benefit:cost ration over total operational costs			1.73			

The STREAM Column

Transforming policy recommendations into pro-poor service provision - the NACA Regional Lead Center in India and the STREAM Initiative working together for change

In eastern India a great many people have been working towards revised procedures and institutional arrangements for service delivery for aquaculture. This work has centered on implementing recommendations that arose from and were prioritized by farmers and fishers¹.

NACA, through DFID NRSP support to its STREAM Initiative, has been working closely with the Central Institute for Freshwater Aquaculture (CIFA), the Regional Lead Center for India. Together they have been supporting government and NGO service providers to implement the recommendations of farmers and fishers, some of which have now become policy in the northeastern Indian states of Orissa, West Bengal and Jharkhand.

A priority recommendation of farmers and fishers was to “develop infrastructure for timely production of fingerlings at local level”

In western Orissa the supply of fingerlings is one of the key constraints to aquaculture development. Some of the government hatchery infrastructure for local seed production has fallen into disrepair. There is also limited human and physical capacity in the government sector for nursing seed to fingerling size, which is the most valuable stage for poor farmers utilizing seasonal water bodies². The Government of Orissa this year undertook an experiment on fingerling production in Nuapara District together with an NGO and a one community-based One-stop Aqua Shop (OAS)³ in West Bengal, which acquired access to ponds for fingerling production and commenced a fingerling supply service.

The experiment involved inexpensive, plastic-reinforced fibreglass hatching and spawning tank designs that were tested by a previous CIFA “Plastics in Aquaculture” project, but which had not yet emerged from on-station trials. It was undertaken by a watershed



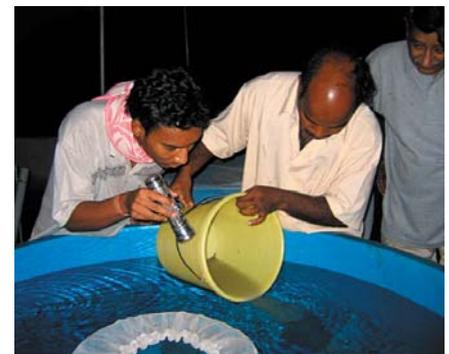
Bilenjore hatchery.

Project Implementing Agency (PIA) of the Western Orissa Rural Livelihoods Project (WORLP), the NGO Sahabhagi Vikas Abhiyan (SVA), with CIFA and NACA through STREAM providing hatchery design and training to operate the system for spawning Indian Major Carps and Common Carp. The hatchery which costs around 1/10th of the cost of a traditional concrete hatchery can produce around 25 million seed.

Fish hatchery Nuapara, Orissa

In addition, SVA and STREAM worked together to plan and operate a network of self-help groups, each with suitable small shallow water bodies, to nurse the seed from the hatchery to fry (25-30 mm) and fingerlings (100-150 mm) in time for stocking both seasonal and perennial water bodies. It is important to link nursing management with hatchery management. This is because it takes longer to prepare a pond to produce an abundant crop of natural feed, to receive first-feeding spawn, than to spawn seed for stocking. Scheduling pond preparation and spawning is a crucial issue for success, with implications for communications and manage-

ment of nursing networks. One small hatchery with a 3-m spawning tank and 3 x 2 m hatching tanks can service 100 SHGs with fish seed over its 30-day period of operation during the rainy season, with a pay-back period (based on capital and operating costs) of two seasons. Each SHG (with on average 3 x 0.02-ha nursery ponds around 1.5-m deep) can realize an operating profit of around \$1,000 over a one-to-two month nursing period. One hundred SHGs produce collectively enough fingerlings to stock around 2,000 ha of water area (several meters deep) with a production capacity of around \$1 million of marketable fish at local rates. In the context of western Orissa, this is an attractive income-generating option for NGOs



Late night spawning.

operating hatchery modules, with interest also from the small-scale private sector, SHGs within a nursing network, and government who wish to increase fish production to match state demand.

The federation of SHGs that operates an OAS in Kaipara Village, West Bengal, has taken ponds for fingerling production on lease, acquired fishing nets and other equipment, which it leases to SHGs. They have commenced a fingerling supply service that satisfies a local demand and provides a return to support the operation of the OAS.

Another recommendation was to extend the lease period of ponds

Single year leases for fish ponds were common but unpopular. A longer timeframe allows for better management and a greater overall return on investment. As a result of positive follow up at national and state levels to this recommendation from farmers and fishers, the pond lease period is now increased to up to five years in Orissa, West Bengal and Jharkhand and efforts are under way to make it easier for Self Help Groups (SHGs) to bid for the leases of their local tanks. There is evidence emerging that the new arrangement is more attractive to SHGs than the annual lease, and that taking on such leases can be beneficial to the improvement and stability of rural livelihoods. An example of a group responding to this change is described in the STREAM story *The Khandkhle-goan Story*⁴.

There is no preference given to local SHGs; the lease auction system remains an open bidding process with the lease going to the highest bidder. The change is that SHGs are being encouraged to bid and are becoming better informed about the timing of auctions. The groups are more organized; more empowered and are developing greater resolve to win auctions. Many still have little guidance on appropriate upper limits for lease bids in relation to potential costs and benefits, so STREAM is currently working with NR International and the Orissa government to provide this.

A third recommendation was for the establishment of 'single-point under-one-roof service provision' and a forth to change how information is made available to farmers

The establishment of local institutions called One-stop Aqua Shops (OASs) is proving popular with SHGs and farmers, as well as service providers. Fisheries Extension Officers find it easier to service the needs of an administrative block if, at least some of the time, farmers can come to them. Banks and suppliers of inputs and services also strongly welcome the opportunity to reach an otherwise disparate market. So far a total of nine OASs have been established. Different OAS models have emerged: an experiment in the reform of the Fish Farmers Development Agency (FFDA) in the government sector of Jharkhand; developments by NGOs in Orissa one associated with a hatchery; and community-based service provision enabled through a federation of SHGs in West Bengal.



NACA through STREAM working with Orissa Watershed Development Mission, the Western Orissa Rural Livelihoods Project and NR International have developed a new series of Better-Practice Guidelines in Oriya language about rural aquaculture for distribution through Orissa's OASs. There are 19 different titles, and so far 95,000 are distributed to OASs in the state.

Yet another recommendation was to 'encourage integrated aquaculture including simplified procedures for accessing government schemes and bank loans'

Extension agencies and financial loan services have rapidly recognized the value of OASs as a focal contact point.



OAS Kaipara Run by Federation of Self-Help Groups.

They are beginning to use OASs for meeting with poor clients and potential poor borrowers.

The State Bank of India encourages the rural banking sector to offer targeted financial services, through local branches, to people who are poor. Encouragingly, this is not altruism, extremely well targeted micro-credit is an excellent business opportunity recognized by the banking sector because of the repayment rates by small-scale entrepreneurs they have experienced. Micro-credit providers, like, for example, Mallyabhum Gramin Bank in West Bengal have welcomed the launch of OAS to help to share information about and opportunities to access their products. Mr Bipra Das Midya, Area Manager, and Mr Ajit Banerjee of Mallabhum Gramin Bank, Purulia (who featured in the *Back to Jabbarah* story and other project reports of DFID NRSP research), have ledger data for loans to SHGs choosing to adopt rural aquaculture with better repayment rates than any other rural income generating options.

So where does all this lead?

The good news is that farmers and fishers have had an opportunity to voice their recommendations for changes. The great news is that their voices have been heard and their recommendations are finding their way into policy; and the early indications are that the resulting policies are popular. The modular approach to developing hatchery infrastructure and an associated network of nursery pond operators (mainly Self-Help Groups), based on the experiment conducted in western Orissa, has been very successful and has been adopted by the Government of Orissa, Orissa Watersheds Development Mission, as a

development plan for improving timely production of fingerlings at local level in its five-year plan (2006-10).

The OAS concept has been carefully nurtured and its implementation is being successfully piloted by different stakeholders in all three states. NGOs have been especially receptive and have developed good facilities. The SHG federation in Kaipara, West Bengal, is using the OAS to draw down the support they need and has implemented many innovative income-generating ideas, providing goods and services for aquaculture locally as well as a source of revenue to sustain the OAS. The developments within the government sector are visible to government and are being monitored; because government outlets are essentially seen as cost-centres, they do not share the flexibility of the voluntary or private sector to become financially self-sustaining. The concept of local-level institutions like OASs generating their own income is

testing the government bureaucracy and its implementation. However, the commitments of staff, infrastructure and materials from different sectors within government have given rise to sustained opportunities for the implementation of the OAS concept.

OAS Kaipara, West Bengal

In an age where previously unprecedented levels of communication are becoming possible even in the most remote of Orissa's rural districts, the OAS has become a focus of improved service provision and is changing the way that information is being made available, which is what farmers and fishers originally requested as a service provision priority. The OAS and local hatcheries enable service providers to get 'closer' to communities through the development of information and service focal points.

We invite your comments and feedback related to the STREAM Column, which can be relayed to:

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All references may be downloaded from:
<http://www.streaminitiative.org>.

1. DFID NRSP R8100 reports.
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Grow-out of juvenile spotted Babylon to marketable size in earthen ponds II: Polyculture with sea bass

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In our previous study (see *Aquaculture Asia* Vol. 10 No. 3, July-September 2005), we conducted a trial growout and economic analysis of monoculture of juvenile spotted Babylon *Babylonia areolata* to marketable sizes in Thailand, in disused earthen shrimp ponds. The enterprise budgets, based on the price of spotted Babylon at farm gate of \$9.00/kg, resulted in a gross return, net return, return to capital and management and return on investment of \$37,936, \$14,691, \$16,932 and 7.38, respectively. This demonstrated the economic feasibility of this approach, offering an alternative crop for farmers during a period in which the shrimp

industry is undergoing a price slump due to an international over supply.

The second part of our research has focused on farming spotted Babylon in polyculture as a measure to increase the production and profitability of the system. Several marine shellfish species have been used in other polyculture systems in the past, augmenting harvests through more efficient use of space and food resources, and the polyculture of shellfish with fish presented some possibility of a complementary arrangement¹. More recently, Chaitanawisuti et al.² reported the results of polyculture of spotted Babylon and Asian seabass *L. calcarifer* in concrete ponds (3.0 x 4.5 x 0.5m), supplied with a flow-through seawater system. Average growth of spotted Babylon was 1.17g/month, survival 96%, FCR 1.34 and total production 29.0kg. While

this trial demonstrated the technical feasibility of the system, the economic feasibility must also be proven for the successful development of spotted Babylon aquaculture operations. We therefore set out to conduct a financial investment analysis tied to biological, production, cost, and market price variables, which we used to make decisions about culture methods and economic viability for commercial operation of this enterprise. The outcome of the analysis was used to develop commercial land-based grow-out operations of spotted Babylon in earthen ponds in Thailand. This article is a summary of our findings and experience.

Pond design and operation

This study was conducted at the Research and Technology Transfer Unit of Thai Babylon Breeding and Culture, Chulalongkorn University, Petchaburi province, Thailand. A total farm area of 0.8 ha was used, comprising 0.3 ha of grow-out earthen ponds, 0.4 ha seawater reservoir and 0.08 ha accommodation and office. Eight 20 x 20m earthen ponds of 1.5m depth were used for the monoculture and polyculture trials. Pond walls were 1.5m in height, 3.0m in width at the base and 2.5 m in width at the top. The pond bottoms were covered with 10-15cm layer of coarse sand. Each grow-out pond was fenced with a plastic net of 15 mm mesh size and 1.2 m in height, supported with bamboo frames for strengthening. We found that the bottom of the plastic net must be buried under the sand to a depth of about 6cm to limit movement of snails along the pond bottom and pond wall, and to ease harvesting. Prior to the start of the grow-out, all ponds were dried for two weeks and then filled with ambient unfiltered natural seawater from a nearby unlined canal to a depth of 70 cm. The seawater intake system was powered by one 5.5-hp engine equipped with water pump of 12.5cm diameter outlet pipe. Two air blowers (2 Hp) were used to supply high volume air for all grow-out ponds. PVC pipes of 2.54 cm in diameter were connected to the outlet of the air blower and extended to the pond dike of each pond. Four polyethylene pipes of 18m length and 1.6cm diameter were connected to the PVC pipe and extended across the pond, suspended approximately 10cm above the bottom with bamboo stakes. Each pipe was pierced with 10 holes of 1.5mm in diameter,



Production of spotted Babylon after harvest.



Production of sea bass after harvest.



And here they are...on sale in a Bangkok restaurant (photo from the Editor's camera phone).



Babylonia are becoming popular throughout the region - these were photographed at Huangsha Live Seafood Wholesale Market in Guangzhou, China.



A 20.0 x 20.0 x 1.5 m grow-out earthen pond for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha.



Close up of seawater inlet and containment fence.



Babylonia seed for stocking.

approximately 2m apart, to provide aeration. Aerators were operated for 16 - 20 hours per day and turned off during feeding.

Polyculture trials

Spotted Babylon and sea bass fingerlings were purchased from a private hatchery. Individuals from the same cohort were sorted by size to minimize differences in shell length and to prevent possible growth retardation of small Babylon by larger individuals. The spotted Babylon juveniles had an average shell length of 1.1cm and body weight of 0.5 g, respectively. Seabass fingerlings were stocked at an average of 12.7cm and 37.2g. The ponds were initially stocked with 200 snails/m² (80,000 snails per pond) and 5 fish/m² (2,000 fish per pond), respectively.

Grow-out operation

Sea bass were fed to satiation with fresh trash fish twice daily in the morning (09:00) and evening (17:00). Spotted Babylon were fed with fresh trash fish to about 15 - 20% of body weight once daily in the morning, after the fish were satiated. The feeding of spotted Babylon was monitored daily using fifty baited traps. The amount of food was adjusted every 30 day after measuring body weight. Fifty percent of seawater was exchanged at 15 day intervals and seawater was sampled before water exchange at 25 cm above pond bottom for analysis of temperature, salinity, pH, alkalinity, nitrite – nitrogen and ammonia – nitrogen following standard methods as described by APHA et al. 1985. Dissolved oxygen was measured daily. Spotted Babylon were cultured until they reached the marketable size of 120-150 snails/kg. Grading by size was not conducted.

Growth

There was no significant difference in the growth rate of spotted Babylon between monoculture and polyculture with seabass. The average growth rate for snails in polyculture over seven months were 0.51 g/month body weight and 0.33 cm/month. At the end of the trial the mean (\pm SE) final body weight of snails was 4.10 \pm 0.57g and shell

length was 3.6 ± 0.75 cm. The food conversion ratio for the trial was 2.71 and final survival was 84.30%.

Production

The size of the snails produced in the trial equates to around 214 ± 43.90 snail/kg and total yield per production cycle was equivalent to 10,450 kg/ha. Around 87.6% of snails were in the size class 100-250 snails/kg and the remainder (12.4%) were <250 snails/kg. The survival of seabass was around 43.9% with a production of 12,270 kg/ha.

Water quality

Salinity and alkalinity showed the greatest changes during the culture period. Salinity ranged from 14–38 ppt and alkalinity 30–88 mg/L, respectively. Other parameters changed more slowly, ranging as follows: Temperature 25-35°, pH 7.9-9.2, dissolved oxygen 3.5-5.6mg/L, nitrite 0.0004–0.0125 mg/L, total ammonia 0.0329–0.2120 mg/L. The fluctuation of water quality parameters within the ponds was generally slower than those observed in the natural seawater, and were generally suitable for safe culture of spotted Babylon.

Economic analysis

Parameters used for the economic analysis for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha in Thailand are summarized in Table 1. Farm data (total farm area, pond sizes, and total pond area), stocking data (average initial weight, stocking density) and harvest data (duration of grow-out, average weight at harvest, final survival, average weight at harvest, feed conversion ratio and yield) are based on the actual data of the pilot farm. The total investment requirement for construction of a 0.8ha farm was estimated to be US\$4,837. The largest cost component was the construction of grow-out ponds and seawater reservoirs (around 35% of the total investment cost), followed by building of canvass nursery ponds (13%), land (10%), seawater pumps (10%) and blowers (10%). These five components of the farm represented a total of 79.08% of total investment (Table 2). Ownership cost per

Fig 1. Growth in body weight of spotted Babylon, *B. areolata*, in polyculture with sea bass in earthen ponds over a period of seven months.

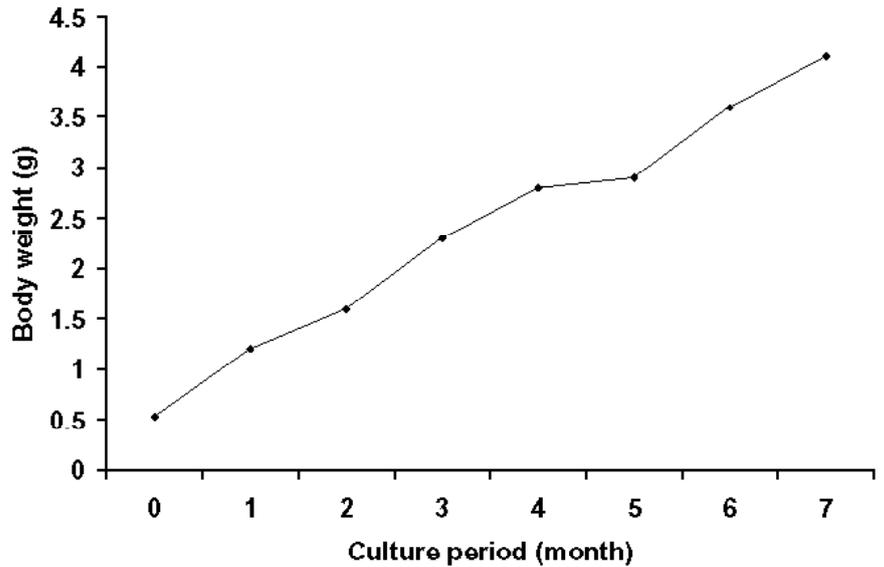
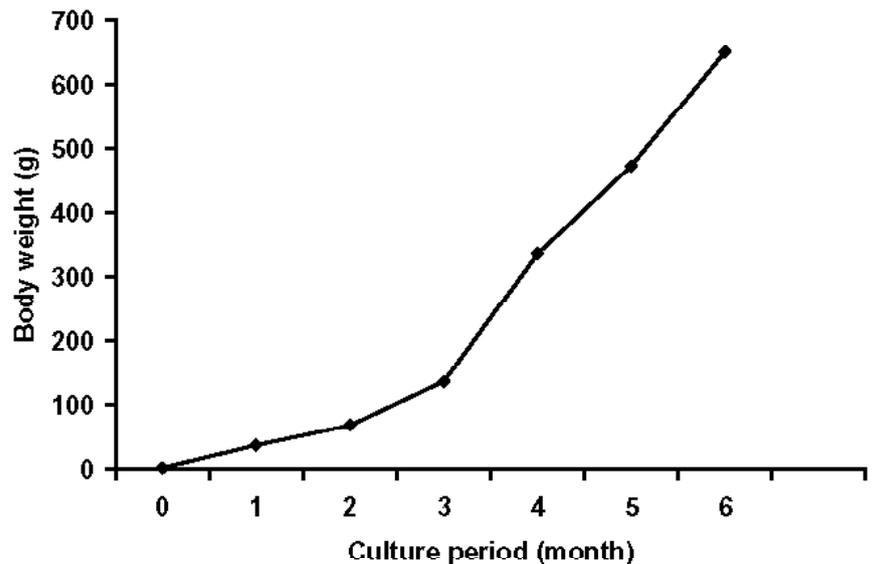


Fig 2. Growth in body weight of sea bass, *L. calcarifer*, in polyculture with spotted Babylon in earthen ponds over a period of seven months.



Sorting the harvest.



Trash fish used for feeding of both spotted Babylon and sea bass.

Table 1. Parameters used for the economic analysis for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha of earthen ponds in Thailand.

Parameter	Value
A. Farm data	
Total farm area (ha)	0.8
Pond size (ha)	0.04
Total pond area (ha)	0.32
Total area of seawater reservoirs (ha)	0.4
B. Stocking data	
Average initial weight of spotted Babylon (g)	0.5
Average initial weight of sea bass (g)	2.3
Stocking density of spotted Babylon (No./m ²)	200
Stocking density of sea bass (No./m ²)	5
C. Harvest data	
Spotted Babylon	
Duration of grow-out (months)	7
Average final weight (g)	6.9
Average final survival (%)	84.30
Feed conversion ratio (FCR)	2.71
Yield per production cycle (kg/ha)	10,450
Farm gate sale price (US\$/kg)	8.75 – 9.25
Sea bass	
Duration of grow-out (months)	6
Average final weight (g)	300 - 1200
Average final survival (%)	46
Feed conversion ratio (FCR)	4.47
Yield per production cycle (kg/ha)	12,250
Farm gate sale price (US\$/kg)	1.89 – 2.25

production cycle was estimated to be US\$2,241. The major ownership cost items were depreciation (accounting for around 76%), land (22%) and interest on investment (about 1.5%) (Table 3). Operating costs per production cycle were estimated to be US\$21,004. The five major operating cost items, rounded to the nearest percentage point, were purchasing of spotted Babylon and sea bass seed (around 62%), feed (16%), hired labor (8%) interest on investment (7%), and electricity and fuels (5%). (Table 4). Total cost per production cycle for polyculture of spotted Babylon and sea bass in a total farm area of 0.8 ha was US\$23,245, of which approximately 10% was the cost of ownership and 90% was operating cost.

The cost of producing spotted Babylon marketable sizes in this grow-out farm design is \$6.95/kg (Table 5). Enterprise budgets of a 0.8ha farm under polyculture of spotted Babylon and sea bass in earthen ponds are presented in Table 6. Under a scenario of a farm gate price of US\$9.00/kg for spotted Babylon and US\$2.35/kg for seabass the gross return of the system is US\$37,936, net return US\$14,691, return to capital \$16,932 and return on investment 3.50. The breakeven farm gate price-point and yield of the pilot farm was \$6.95/kg for spotted Babylon at a production of 2,582 kg per cycle. Cash-flow budgets were developed to examine profitability in relation to the timing of expenditures and earning. Under the farm data, stocking data and harvest data obtained in this study, a farm gate price of \$9.00/kg results in a positive cash flow by year two (Table 7).

A positive net return and a payback period of less than five years are often used as business investment criteria. Under the farm design and prevailing economic circumstances of this study polyculture of spotted Babylon and Asian seabass is both technically and economically feasible, although there is much scope to improve culture efficiency through investigations to optimize pond design, water depth, feeding strategies (particularly feed competition) and water and pond management. The profitability also can be improved by targeting production, decreasing the culture period to 5-6 months, reducing

the juvenile price to \$0.01/piece and conducting more than one production cycle per year.

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Table 2. Estimated investments requirement for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha of earthen ponds in Thailand.

Item	Investment (US\$)	% of total cost
Land rental	500	10.34
Construction of eight 20 x 20 x 1.5m grow-out earthen ponds and one 0.4ha seawater reservoir	1,700	35.14
Construction of accommodation and storage house	250	5.17
Construction of four 3.0 x 5.0 x 0.7 m canvass nursery ponds and housing	625	12.92
Water pumps and housing	500	10.34
Blowers and housing	500	10.34
Traps for sampling and harvesting	100	2.06
Operating equipment (PVC pipes, plastic tanks, lighting, salinometer, thermometer, etc.)	162	3.35
Miscellaneous	500	10.34
Total investment	4,837	100

Table 3. Estimated ownership costs per production cycle for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha of earthen ponds in Thailand.

Item	Investment (\$)	% of total cost
Land	500	22.31
Depreciation		
Construction of grow-out earthen ponds and seawater reservoirs	340	15.17
Construction of accommodations and facilities	125	5.58
Construction of canvass nursery ponds and housing	312	13.92
Water pumps and housing	250	11.16
Blowers and housing	250	11.16
Traps for sampling and harvesting	1000	4.46
Equipment (PVC pipes, plastic tanks, lighting, salinometer, thermometer, etc.)	81	3.61
Miscellaneous	250	11.16
Interest on fixed cost	33	1.47
Total ownership cost	2,242	100

Table 4. Estimated operating costs per production cycle for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha of earthen ponds in Thailand.

Item	Investment (US\$)	% of total cost
Spotted Babylon seed	11,200	53.32
Seabass seed	1,800	8.57
Fuels and lubricants	586	2.79
Electricity	378	1.80
Feed for spotted Babylon	1,358	6.47
Feed for seabass	1,920	9.14
Labour (2 full time)	1,750	8.33
Repairs and maintenance	375	1.79
Ice for feed storage	108	0.51
Interests on operating capital	1,529	7.28
Total operating cost	21,004	100

Table 5. Estimated total cost per production cycle for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha of earthen ponds in Thailand.

Item	Investment (\$)	Percent of total cost
Ownership costs	2,241	9.64
• Land	500	2.15
• Depreciation	1,708	7.35
• Interest on investment	33	0.14
Operating costs	21,004	90.36
• Spotted Babylon juveniles	11,200	48.18
• Sea bass juveniles	1,800	7.74
• Fuel and lubricants	586	2.52
• Electricity	378	1.63
• Feed for spotted Babylon	1,358	5.84
• Feed for sea bass	1,920	8.26
• Hired labour	1,750	7.53
• Repairs and maintenance	375	1.61
• Ice for storage of feed	108	0.47
• Interests on investment	1,529	6.58
Total cost per production cycle	23,245	100

Table 6. Enterprise budgets of a total farm area of 8,000 m² for polyculture of spotted Babylon with sea bass in a total farm area of 0.8 ha of earthen ponds in Thailand.

Parameter	Value
Production	
Spotted Babylon* (kg)	3,344
Sea bass* (kg)	3,920
Costs per production cycle	
Initial investment requirements	4,837
Ownership costs (\$)	2,241
Operating costs (\$)	21,004
Total cost (\$)	23,245
Returns	
Gross return (\$)	37,936
Net returns (\$)	14,691
Return to capital and management (\$)	16,932
Return on investment	3.50
* Total yield of spotted Babylon and sea bass per production cycle at 0.4 ha	
- Price at farm gate for spotted Babylon and sea bass of \$9.00 and \$2.25/kg, respectively	

Table 7. A seven-year cash flow for polyculture of spotted Babylon with sea bass using a total area of grow-out earthen ponds of 0.4 ha in Thailand. A stocking density of spotted Babylon of 200 snails/m² and price at farm gate of \$9.00/kg.

Item	Year 1 (\$)	Year 2 (\$)	Year 3 (\$)	Year 4 (\$)	Year 5 (\$)	Year 6 (\$)	Year 7 (\$)
Investment	4,837	-	-	-	-	-	-
Ownership cost	2,241	2,241	2,241	2,241	2,241	2,241	2,241
Operating cost	21,004	21,004	21,004	21,004	21,004	21,004	21,004
Total cost	28,082	23,245	23,245	23,245	23,245	23,245	23,245
Gross return	37,936	37,936	37,936	37,936	37,936	37,936	37,936
Net return	14,691	14,691	14,691	14,691	14,691	14,691	14,691
Cumulative	-13,391	1,300	15,991	30,682	45,373	60,064	74,755



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A practical guide to feeds and feed management for cultured groupers



A guide to small-scale marine finfish hatchery technology



Influence of economic conditions of importing nations and unforeseen global events on grouper markets

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Groupers, family Serranidae, are a group of expensive marine finfish species often served in most dining banquets in Southeast Asian countries. The grouper species that are commonly found in the seafood markets belong to the Sub-family Epinephelinae and can be divided into three commonly cultured species groups, i.e. *Cromileptes*, *Epinephelus* and *Plectropomus*, which are normally traded either live or fresh chilled in seafood markets. Groupers that are sold whole are generally small or plate-size fishes ranging from 300 g to 1 kg, greater than 1 kg are sold as fillet or block. Fresh chilled grouper is sold at discounted rates, generally 25-30% lower in comparison to the live form. Therefore, many farmers in the Asia-Pacific region concentrate on farming and selling live grouper. The demand for live grouper mainly comes from China, Hong Kong, and to a lesser extent Malaysia, Singapore and Taiwan.

Cultured grouper amounts to only 8.6% of 52,000 t of the total wild caught grouper production in Asia, valued at US\$238 million (FAO, 2003). Cultured grouper production is on an upward trend, increasing from 0.1 % in 1983 to 1.5% in 2003 in terms of

contribution to total marine food fish production (FAO, 2003).

Most grouper are cultured in floating net cages either in the open sea or at the seaward end of estuaries. Many farms fatten wild caught fingerlings and juveniles and in this situation monoculture is not the usual practice as wild seed is typically supplied as a mix of species. The major constraints for grouper aquaculture have been the inconsistent supply of fingerlings and artificial diets for grow-out. The depletion of wild seed stock has led to the development of grouper hatchery technology in the region, particularly in China, Indonesia, Malaysia, Taiwan and Thailand. Hatchery survival rate for many grouper species in the region is still low, ranging from less than 2% to around 10% (Lim 1993), but generally being less than 5% (Sugama et al., 1999). However, the very high fecundity of grouper species compensates for this low survival, helping to make hatchery operations viable (Bunliptano and Kongkumnerd, 1999).

Most grouper farmers in the region still use trash fish as the main feed in culture operations. Artificial feeds are used in grouper culture in Indonesia, Hong Kong, and Taiwan, but



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the adoption of artificial feeds is still relatively limited. This article evaluates the economic conditions of importing countries and the impact of unforeseen global events on market susceptibility, and consequently on grouper culture.

Materials and methods

Official statistics on import of live marine food fish from 1999 to 2004 were obtained from the Agriculture, Fisheries and Conservation Department (AFCD) of Hong Kong, which in turn is based on Hong Kong Trade Statistics of the Department of Census and Statistics. The statistics on grouper species were abstracted from the original live marine food fish data. Statistics on the consumption of live marine food fish in Southern China were not available, therefore discussion on grouper consumption and market trends are based on Hong Kong statistics only.

The wholesale market prices for various live marine finfish species were obtained from two major markets websites in Hong Kong and Southern China. These websites provide daily updates on the wholesales prices for the major live marine food fish species traded in Hong Kong and Southern China. These two websites are:

- Fish Marketing Organization (FMO), Hong Kong (<http://www.fmo.org.hk/indexeng.html>) is a self-financing, non-profit organization. The FMO currently operates seven wholesale fish markets in Hong Kong.
- Huangsha Live Seafood Wholesale Market in Guangzhou, Southern China (<http://www.gzhsfisher.com/index2.php>), is the biggest live seafood market in China.

The wholesales grouper prices from these two markets were collected daily through the internet. Additional market information and market prices in China, Hong Kong, Indonesia, Thailand and Vietnam were collected during field visits.

The gross domestic product (GDP) statistics for Hong Kong and China were collected for the period from 1996-2004. GDP is the most widely used indicator to determine the economic conditions of a given nation by economists. If GDP is lower, the economic conditions of a given nation will

be weaker and hence the employment and income will be affected negatively.

In addition, the timing of a Severe Acute Respiratory Syndrome (SARS) outbreak and World Health Organization (WHO) warnings were also collected to examine the correlation between extra-ordinary events and its affect on economic conditions.

A time series analysis based on these data was carried out to look at the effects of economic conditions on volume imported; SARS outbreak on demand; price fluctuation during SARS period; and the avian bird flu on price and demand.

Findings

General markets

Use of live grouper is often limited to Chinese cuisine, and consequently China and Hong Kong are the two main markets. These markets are limited but lucrative with a total of HK\$ 719 million of grouper imported into Hong Kong in 2004, although this is significantly lower (19.8%) than the 2000 level of HK\$ 896 million. In accordance with marketing theory grouper can be considered as a "niche market" product, which caters to a small, specialized segment of the seafood market with high return (Kotler, 1991). The quantities of live grouper and other marine finfish species and the value of the imports from 1999 to 2004 are given in Tables 1 and 2, respectively. It is evident that grouper accounted for 56.7 to 52.6 % and from 77.9 to 82.4 % of the total imports in volume and in value, respectively, indicating the importance of grouper in the live seafood market in Hong Kong.

Although Hong Kong also farms marine food fish, the quantity produced from local farms can only satisfy 12% of the total live fish demand. In 2003, the total cultured fish production in Hong Kong was around 1,500 t, valued at US\$9.7 million. Hong Kong has a total population of 6.8 million, with an annual per capita consumption of fish of around 37 kg (Sim *et al.*, 2004). The remaining 88% of the live food fish demand can only be satisfied by imports, particularly from Asian countries. The details of each country that exported live marine food fish into Hong Kong

for the period from 1999 to 2004 are presented in Table 3 (volume) and Table 4 (value), respectively.

Since 1997, the market for high value live marine food fish species, particularly groupers, has experienced “demand shocks” that are thought to have been brought about by two major incidents. The first was the Asian financial/economic crisis that occurred

in 1997, which brought down a majority of Asian economies and currencies, including Hong Kong, which experienced a sharp 10% decline from 1997 to 1998. The second was the outbreak of diseases such as the severe acute respiratory syndrome (SARS) in Hong Kong in 2003, which caused business and leisure travel to drop significantly.

Effects of general economic factors on markets

In 1996, Asian countries such as Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand were growing rapidly with the real GDP growth ranging from 4.9 to 8.6% (Karunatileka, 1999). In July 1997, the Asian economic crisis

Table 1: Imported quantities (tonnes) of various live marine food fish into Hong Kong from 1999 to 2004. The percentage contribution of grouper to the total volume of imports is given in percentage.

Species	1999	2000	2001	2002	2003	2004
Green Grouper	2,128,792	3,702,581	1,763,506	1,500,925	2,169,574	1,939,592
Other Grouper species	2,127,960	2,226,945	2,283,640	1,716,752	1,516,834	1,438,046
Tiger Grouper	495,520	172,014	343,408	418,297	488,488	588,142
Flowery Grouper	787,623	265,695	324,658	344,431	250,814	366,649
Giant Grouper	31,936	23,894	27,605	31,707	62,460	87,447
Humpback Grouper	18,475	14,969	18,135	26,374	8,760	27,191
Sub-total - Grouper	5,590,306 (41.2%)	6,406,098 (42.4%)	4,760,952 (39.4%)	4,038,486 (33.9%)	4,496,930 (37.1%)	4,447,067 (33.4%)
Leopard Coral Trout	1,754,478	2,649,263	2,301,554	2,468,726	2,337,101	2,452,218
Spotted Coral Trout	350,056	202,374	256,589	317,837	199,803	104,260
Sub-total – coral trout	2,104,534 (15.5%)	2,851,637 (18.9%)	2,558,143 (21.2%)	2,786,563 (23.4%)	2,536,904 (20.9%)	2,556,748 (19.2%)
Other Marine Fish	3,653,129	5,037,069	4,163,289	4,689,351	4,899,884	6,069,041
Mangrove Snapper	1,912,875	613,752	494,838	238,619	101,800	185,150
Humphead Wrasse	104,129	81,572	36,952	48,673	46,401	33,471
Other Wrasses & Parrotfish	217,598	109,160	70,538	102,856	39,817	14,572
Sub-total – other marine fish	5,887,731 (43.3%)	5,841,553 (38.7%)	4,765,617 (39.4%)	5,079,499 (42.7%)	5,087,902 (42.0%)	6,302,234 (47.4%)
Total (kg)	13,582,571	15,099,288	12,084,710	11,904,546	12,121,736	13,305,779

Source: Hong Kong Trade Statistics from Census and Statistics Department (1999 to 2004).

Table 2: Imported value (HK\$ '000) of various live marine food fish into Hong Kong from 1999 to 2004. The percentage contribution of grouper to the total value of imports is given in percentage.

Species	1999	2000	2001	2002	2003	2004
Green Grouper	150,057	214,598	117,011	102,207	119,089	100,400
Other Groupers	154,515	163,212	226,536	190,035	130,871	110,704
Tiger Grouper	55,195	17,573	43,647	61,509	50,824	60,564
Flowery Grouper	99,681	32,047	40,277	47,611	31,881	42,214
Giant Grouper	4,689	2,189	3,795	4,471	6,872	9,361
Humpback Grouper	7,302	6,141	7,243	10,500	3,070	13,253
Sub-total - grouper	471,439 (45.5%)	435,760 (39.9%)	438,509 (45.1%)	416,333 (42.3%)	342,607 (40.5%)	336,496 (38.5%)
Leopard Coral Trout	276,716	427,381	314,648	366,566	344,692	367,903
Spotted Coral Trout	58,977	32,669	54,199	43,529	26,247	14,955
Sub-total - coral trout	335,693 (32.4%)	460,050 (42.1%)	368,847 (37.9%)	410,095 (41.7%)	370,939 (43.9%)	382,858 (43.9%)
Other Marine Fish	113,901	152,069	119,246	111,885	109,093	135,133
Mangrove Snapper	78,915	27,794	22,727	9,710	3,223	5,458
Humphead Wrasse	23,858	13,556	10,293	13,451	11,839	10,118
Other Wrasses & Parrotfish	11,884	4,190	13,503	23,011	7,627	2,975
Sub-total - other marine fish	228,558 (22.1%)	197,609 (18.0%)	165,769 (17.0%)	158,057 (16.0%)	131,782 (15.6%)	153,684 (17.6%)
Total (HK\$)	1,035,690	1,093,419	973,125	984,485	845,328	873,038

Source: Hong Kong Trade Statistics from Census and Statistics Department (1999 to 2004).

Table 3: Live marine food fish imported quantity (tonnes) into Hong Kong by country from 1999-2004.

Countries	1999	2000	2001	2002	2003	2004
Thailand	3,537.8	2,990.0	3,018.6	3,020.3	3,181.9	2,755.5
China	1,175.9	1,844.6	1,816.9	2,089.2	2,605.1	2,731.5
Philippines	661.8	1,214.6	1,205.5	1,433.3	1,584.5	1,557.7
Australia	440.6	750.3	1,152.3	1,392.7	1,136.7	981.5
Indonesia	1,097.7	1,167.5	1,284.3	1,193.5	999.7	1,040.6
Malaysia	782.7	501.8	483.3	497.2	644.1	965.4
Taiwan	1,080.2	1,030.6	471.4	102.0	207.2	314.7
Japan	0.7	55.5	60.4	77.9	87.8	129.3
Maldives	66.5	38.0	113.5	59.0	57.0	80.1
Cambodia	20.4	38.5	35.8	43.6	43.5	27.1
Vietnam	191.0	188.4	200.0	131.9	23.2	45.1
Others	98.4	61.2	115.8	126.5	49.0	65.8
Total (kg)	9,153.5	9,880.9	9,957.7	10,166.8	10,619.9	10,696.3

Source: Hong Kong Trade Statistics from Census and Statistics Department (1999 to 2004).

Table 4: The value of live marine food fish imported into Hong Kong (in HK\$ '000) by country from 1999-2004.

Countries	1999	2000	2001	2002	2003	2004
Australia	58,950.1	107,575.0	150,529.2	205,148.3	162,235.2	167,369.0
Philippines	65,857.6	124,587.0	121,261.0	140,375.0	155,107.7	140,231.0
Indonesia	127,147.4	128,460.7	153,842.6	144,338.2	122,415.6	114,800.0
Thailand	175,014.6	131,143.8	137,608.1	95,761.1	100,912.9	89,495.0
Malaysia	72,044.7	62,879.3	60,478.8	56,800.7	54,543.8	71,611.0
China	16,850.4	24,666.4	28,267.2	31,352.1	36,654.1	28,428.0
Taiwan	53,398.9	41,047.9	22,343.0	7,414.9	14,980.9	24,218.0
Maldives	7,055.0	4,500.0	11,178.0	5,604.0	5,470.0	7,855.0
Japan	45.3	833.1	905.9	2,024.5	3,776.9	9,538.0
Cambodia	947.2	3,333.0	1,954.6	1,839.2	2,140.0	1,898.0
Vietnam	15,560.1	14,378.5	14,222.4	9,214.9	1,948.8	2,689.0
Others	10,195.1	6,574.6	11,354.6	9,895.8	4,656.2	5,657.0
Total	603,066.4	649,979.2	713,945.3	709,768.6	664,841.9	663,789.0

Source: Hong Kong Trade Statistics from Census and Statistics Department (1999 to 2004).

began to affect regional economies and Hong Kong, although its currency was pegged to the US dollar at HK\$1 = US\$0.1282, also suffered significantly with a sharp decline of GDP growth from 5.1% in 1997 to -5.0% in 1998. During this period, the importation of live marine food fish into Hong Kong experienced a sharp 15% or 4,132 t decline (Pawiro, 2000). A further decline of -42.45% was experienced in 1999.

The increase in consumption of live marine food fish such as groupers only experienced positive growth of 11.2% or 1,516 t in 2000, after an impressive real GDP growth of 10.2%. This trend, however, was not maintained as the import volume for 2001 dropped by 20.0% as the economy contracted again from 10.2% (2000) to 0.5% (2001). A further import decline of 1.53% in 2002 was linked with weak real GDP growth rate of 1.9%. The import volume for

live marine food fish picked up in 2003 by 1.87% (12,122 t) and 2004 by 9.77% (13,306 t), which were linked to real GDP of 3.2% and 7.5%, respectively. Figure 1 shows the percentage increase and decrease of the live marine food fish imported into Hong Kong in relation to the real GDP rates from 1997 to 2004, both rates are moving in the same direction i.e. as economic condition improve, the import quantity increase and vice versa.

Severe Acute Respiratory Syndrome (SARS) outbreaks

The SARS epidemic in 2003 spread to 29 countries and three regions, with a total of 8,422 cases and 916 deaths by August 7, 2003. The most severely affected countries were China, Hong Kong, Taiwan and Singapore (Siu and Wong, 2004). Table 5 provides a list of

dates and events that are of importance during the SARS epidemic period that were relevant to Hong Kong and that had significant effects on the inbound tourism and visitors, and thus the economic conditions.

The effects of SARS on grouper demand were indirect and in two ways. Firstly, SARS outbreaks in the region had devastating effects on business and leisure travel into Hong Kong, causing them to fall by an estimated 80-90% (Fung, 2004) during the SARS period. Visitor arrivals in Hong Kong experienced a 57.9% drop during second quarter of 2003, which brought growth rate down to -6.2% for the whole year (Table 6). Tourism related income, both for inbound tourism and overnight visitor expenditure, contributed HK\$ 74.93 billion in 2003 (Siu and Wong, 2004).

Secondly, domestic demand was also affected, collapsing during the SARS outbreak period. The local press in Hong Kong reported that restaurant and retail outlets experienced a 10-50 % drop in sales. People who were employed in the tourism and service industries were the most affected, resulting in increase in unemployment and under-employment during the SARS epidemic period (Siu and Wong, 2004).

Market price fluctuations

Due to limited access to market prices in Hong Kong for live marine food fish prior to December 2002 the following analysis only examines the impact of the SARS outbreak on grouper market prices in Hong Kong, particularly for the three main grouper species namely *Epinephelus fuscoguttatus* (tiger grouper), *E. coioides* (green grouper), and *Plectropomus leopardus* (coral trout), and one snapper species *Lutjanus argentimaculatus* (mangrove snapper) for comparison.

The selection of these species is based on their specific characteristics. Coral trout is a high priced species and majority of the supply comes from wild capture. Tiger grouper, green grouper and mangrove snapper are mostly cultured from hatchery produced fingerlings. Tiger grouper and green grouper are medium and low priced grouper species, while mangrove snapper is a low priced substitution.

Green grouper, tiger grouper and mangrove snapper experienced a decline in wholesale price during the SARS period (Figure 2). Green grouper was the most affected, price being reduced from a peak average of US\$13.63/kg to US\$8.63/kg, a 36.7 % decline. Tiger grouper and mangrove snapper also followed similar trends with average prices of US\$20.42/kg to US\$17.63/kg, and US\$6.71/kg to US\$5.24/kg, a 13.8% and 21.9% decline, respectively. However, for wild caught species such as coral trout, the trend was reverse. The wholesale price for coral trout during the same period experienced a 17.9% increase (Figure 2).

Figure 1: The moving trend of the quantity of live marine fish imported into Hong Kong to the Real GDP, from 1997 to 2004.

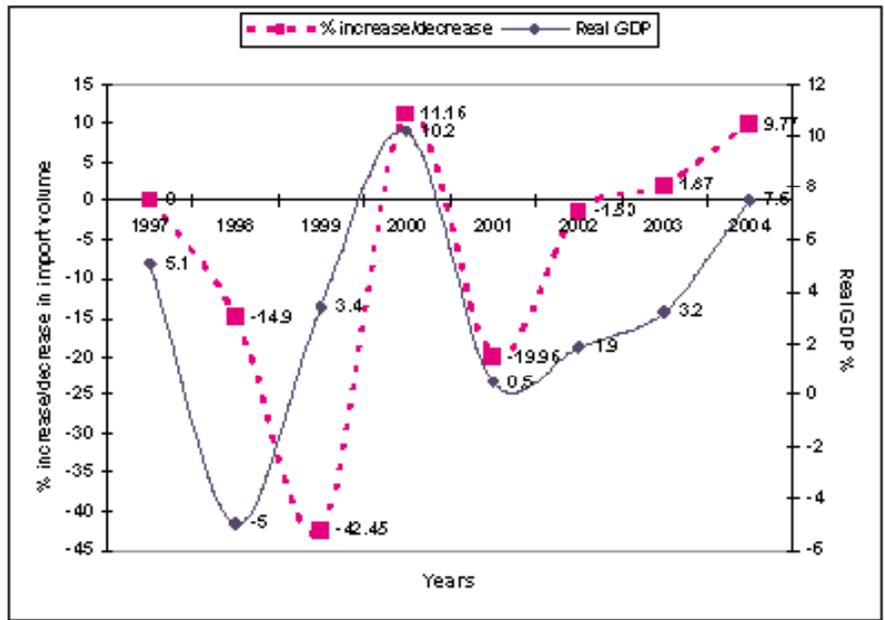
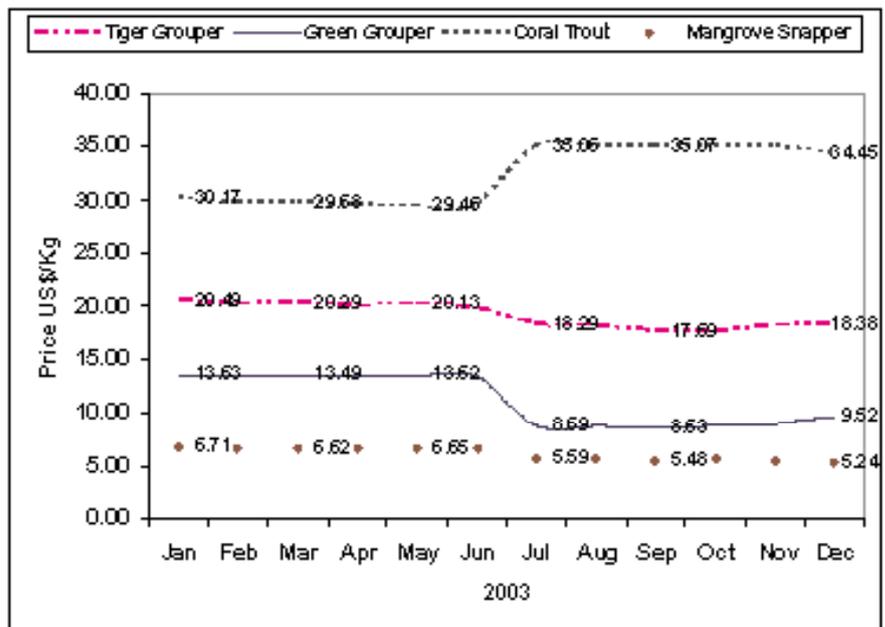


Figure 2: Green grouper, tiger grouper, mangrove snapper and coral trout average wholesale prices in Hong Kong from January to December 2003 (Source: FMO).



Avian bird flu effects on market Prices

A seafood market survey was conducted in Hong Kong and Southern China during June 2004, as an activity under the Asia-Pacific Marine Finfish Aquaculture Network. The survey provided an insight into the effect on demand and market prices of live marine food fish during the Avian Bird Flu outbreak period in the region that began in December 2003 (CDC, 2004).

Many countries were affected including China, Indonesia, Singapore, Thailand and Vietnam. Avian influenza strains A (H5N1) normally infect birds exclusively, however, it has recently been found that the avian influenza can also be transmitted to other animals such as pigs, cats, etc. (WHO, 2004a; WHO, 2004b; WHO, 2004c; WHO, 2004d; WHO, 2004e).

The fear of disease transmission from poultry products to humans probably contributed to a switch in consump-

tion from meats to seafood, particularly fish during the avian influenza period (Wu Guo Can and Kwo Hua Wee, pers. comm.), a view also held by the Mr Ye Huan Qiang, Deputy Secretary General, Guangdong Fisheries Association (pers. comm.).

Although the consumption statistics were not available for detailed analysis, the wholesale market prices in Southern China provide useful information for determining the demand for marine food fish during this period. Demand and price are generally interrelated, higher demand pushing prices upwards, if supply remains constant.

Figure 3 shows that the average green grouper price in Southern China increased from US\$9.24/kg to above US\$10/kg from January-December 2004. However, the average market price for tiger grouper remained stable within a range of US\$17.4-US\$22.11/kg, but the trend was for it to increase slightly (Figure 3). The average market price of coral trout was also maintained at US\$44.44-US\$62.26 for the period, and showed an upward trend, particularly after July 2004 (Figure 3). The market prices for these three grouper species show a slight spike over the January-February 2004, the period around Chinese New Year (CNY).

There are two other grouper species that showed a very clear upward move in market prices in Southern China; *E. lanceolatus* (giant grouper) and *C. altivelis* (humpback grouper). Giant grouper is a moderately priced grouper with an average wholesale market price of US\$13.79-US\$25.22/kg (Figure 4). The market price showed an upward trend from December 2003 to December 2004. On the other hand, humpback grouper, the highest priced grouper, averaged US\$79.56-US\$109.57/kg also showed an upward trend (Figure 4).

Discussion

Grouper species are sought after in Hong Kong for wedding and birthday banquets, other celebrations, and business receptions. As a “luxury” food item, their consumption is related to the strength of the Hong Kong economy. The percentage of imported grouper tracks the rise and fall of Hong Kong’s real GDP (Figure 1). On the other hand, low priced substitute species such as

Figure 3: The wholesale price of tiger grouper, coral trout and green grouper in Southern China from December 2003 to October 2004 (Source: Huangsha Live Seafood Wholesales Market).

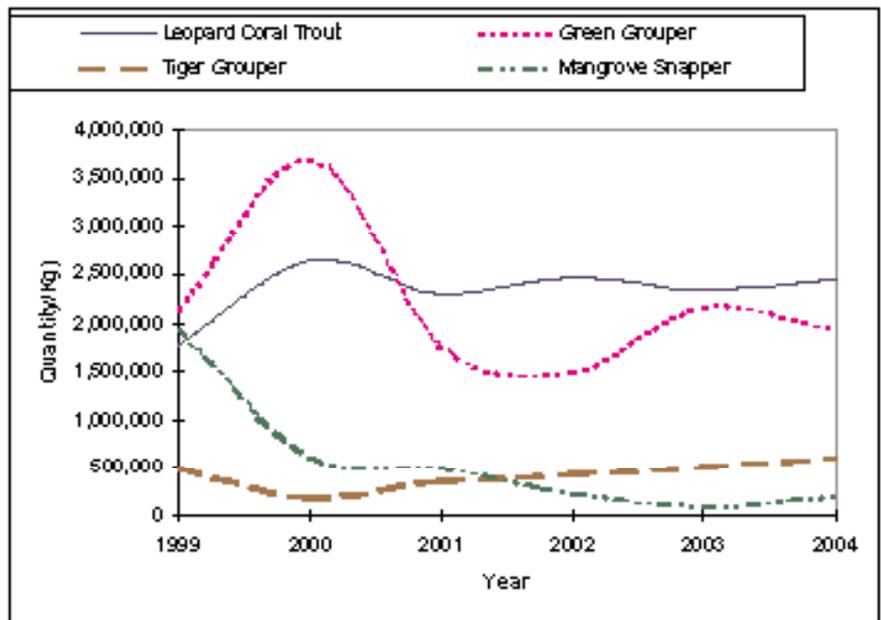
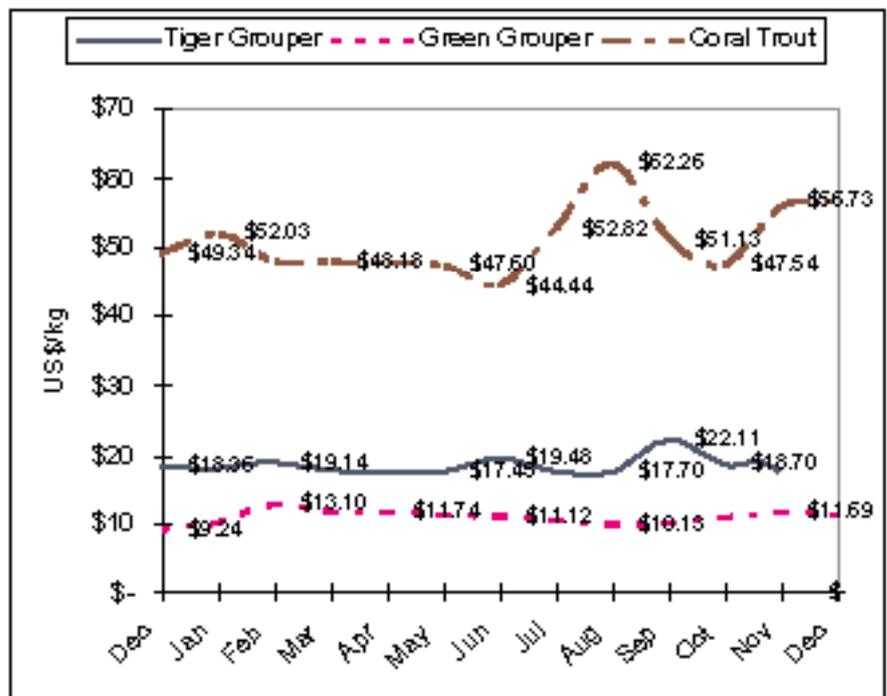


Figure 4: Giant grouper (a) and humpback grouper (b) wholesale prices in Southern China from December 2003 to October 2004 (Source: Huangsha Live Seafood Wholesales Market).



mangrove snapper faced a sharp decline in imports from 1,913 t in 1999 to 185 t in 2004, as economic conditions began to improve (Figure 5). Basically, consumers change their consumption patterns according to economic conditions, which determine their purchasing power. Bennett’s Law asserts that as income rises, consumption patterns

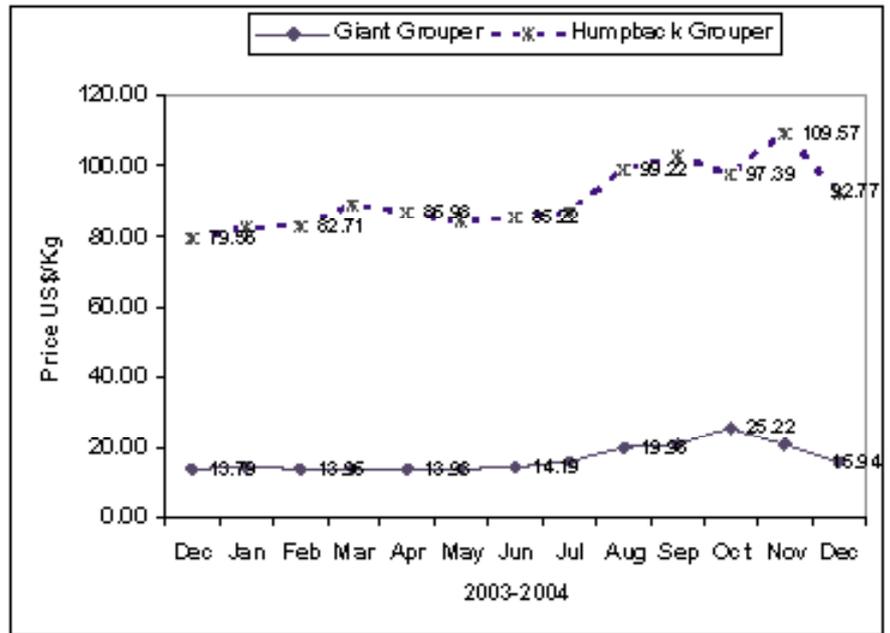
change and move away from staple foods toward higher-quality foods; people eat foods considered more enjoyable, and eat out more often (IFPRI 2003, Putnam and Allshouse, 1997). The reverse situation was observed in 1997 (Skoufias 2003; Rosegrant and Ringler 2000) when the Asian economic crisis and its intensification in

1998 led to demand pattern changes and increasing price- and income-sensitivity by consumers, who moved away from more expensive foods, switching to staple foods such as cereals.

Economic conditions can also be affected by various indirect extraordinary events such as terrorist attacks and influence disease outbreaks. The terrorist attacks on the World Trade Center (USA) on September 11, 2001 and Bali Bombing in October 2002 had a negative influence on the tourism industry in the region. However, the SARS outbreak had a more severe affect causing business and leisure travel to decline, domestic demand to contract and unemployment to escalate in Hong Kong. APEC (2004) reported that the quarterly GDP in Hong Kong for 2003 were 4.4%, 0.6%, 4.0% and 4.9%, respectively. Therefore, SARS became a major draw back on the Hong Kong economic growth for 2003, particularly for the second quarter. Restaurants are traditionally the places serving medium- and high-value marine food fish such as grouper. A total of 50 restaurants in Hong Kong closed temporarily during the SARS outbreak period, and the effects were significant, impacting on some 20,000 people working in the restaurant business (Sim *et al.*, 2003).

Being the largest market for live grouper, Hong Kong economic conditions have a powerful effect on regional supply and prices. Although the SARS outbreak peaked in April 2003, the impact on grouper prices did not occur until July 2003. Cultured species such as green grouper, mangrove snapper and tiger grouper experienced a sharp decline in Hong Kong wholesales prices in July 2003 by 35%, 14.9% and 7.9%, respectively. On the other hand, the price trend for wild caught species such as coral trout appeared to be reversed (Figure 2).

Figure 5: The import quantities of four major marine food fish species during the years 1999-2004.



Guangzhou, Southern China.

Table 5: Total live marine food fish imported into Hong Kong from 1997 to 2004 in relation to GDP.

Year	Import quantity of marine fish (tonnes)	% increase /decrease	Real GDP growth (%)
1997	27,735	NA	5.1
1998	23,603	-14.90	-5.0
1999	13,583	-42.45	3.4
2000	15,099	11.16	10.2
2001	12,085	-19.96	0.5
2002	11,900	-1.53	1.9
2003	12,122	1.87	3.2
2004	13,306	9.77	7.5

Table 6: The important dates and events on SARS outbreak period for Hong Kong.

Date	Event
November 16, 2002	The first case of an atypical pneumonia is reported in the Guangdong province in southern China.
March 11, 2003	Outbreak of a mysterious respiratory disease is reported among healthcare workers in Hong Kong.
March 12, 2003	WHO issues a global alert about a new infectious disease of unknown origin in both Vietnam and Hong Kong.
March 15, 2003	WHO issues a heightened global health alert about the mysterious pneumonia with a case definition of SARS as after cases in Singapore and Canada are also identified. The alert includes a rare emergency travel advisory to international travels, healthcare professionals and health authorities. CDC issues a travel advisory stating that persons considering travel to the affected areas in Asia (Hong Kong, Singapore, Vietnam and China)
April 2, 2003	WHO issues its first travel warning recommending that all non-essential travel to Hong Kong and Guangdong province be postponed.
April 9, 2003	WHO investigative team gives initial report on Guangdong outbreak. The team found evidence of "super spreaders" who were capable of infecting as many of 100 persons.
April 23, 2003	WHO adds Toronto, Beijing, and the Shanxi province of China to the list of regions travelers should avoid to reduce the risk of becoming infected with SARS and taking the deadly disease back home with them. WHO officials say the travel advisory will remain in effect for at least the next three weeks.
May 17, 2003	WHO extends its travel warning to include Hebei province, China. A similar warning to postpone all non-essential travel is in effect for Hong Kong, Taipei, Taiwan and several other areas of mainland China, including Beijing, Guangdong, Inner Mongolia, Shanxi and Tianjin.
May 23, 2003	The WHO lifts its advisory against all but essential travel to Hong Kong and the Guangdong province of China saying the SARS situation in those areas has improved significantly.
June 13, 2003	WHO lifts its travel warning against nonessential travel to several provinces in China, including Hebei, Inner Mongolia, Shanxi and Tianjin.
June 17, 2003	WHO lifts its travel warning against nonessential travel to Taiwan. CDC downgrades its travel warning for mainland China to a travel alert, although a travel warning from both the CDC and WHO remains in effect for Beijing
June 23, 2003	WHO removes Hong Kong from its list of areas with recent local SARS transmission after 20 days passed since the last SARS case was reported and isolated, which breaks the chain of human-to-human transmission and eliminates the risk of infection for both local residents and travelers.
June 24, 2003	WHO removes its last remaining SARS travel warning for Beijing, China. The city was also removed from the WHO's list of areas with recent SARS transmission after 20 days passed since the last new SARS case was isolated.
June 25, 2003	CDC downgrades its SARS travel advice for Beijing, China and Taiwan from "advisory" to "alert" status, which does not advise against travel to the regions but informs travelers of a SARS health concern and advises them to take precautions.
July 9, 2003	CDC lifts its SARS travel alert for Hong Kong retroactively to July 1 because the last SARS case there was reported on May 31.

Source: WebMD (<http://my.webmd.com/>)

The explanation of different in price trends for wild caught and farmed grouper species can be twofold. Firstly, fishers capture wild caught species on a daily basis and if the demand is weak fishing is curtailed. Supply will rapidly be reduced and the price consequently is increased, as in the case of coral trout. It is also believed that traders can manipulate the wholesale price of this moderately high priced species by limiting the supply of the available stocks to the market. Traders may also apply pressure on the farm gate price in order to maintain their profit margins, even under adverse conditions, such as during the SARS epidemic (Jim Chu, pers.

comm.). Secondly, farmed species are kept in cages or ponds and require daily feeding. If the groupers are of marketable size the farmers still need to sell them even if the price is low in order to maintain a cash flow because the cost to feed and maintain marketable sized groupers is significant. The same situation applied to Thai and Vietnamese grouper farmers in 2003 during SARS period. In Khanh Hoa, Vietnam, farmers were reported to have had in excess of 300 t of market sized groupers in ponds and cages, waiting for buyers (Buu and Clausen, 2003). As a result of the excess supply the farm gate price of green grouper in Vietnam dropped from

US\$5.82/kg in 2002 to US\$3.10/kg for 2003 (Buu and Clausen, 2003). In Southern Thailand, the farm gate price for *E. coioides* dropped to Baht 120/kg in 2003, but in September 2004, the price recovered to Baht 240/kg level (US\$1 = Baht 40).

In May 2003 most of the live reef fish exporters in Bali suspended trading activities, as the demand decreased significantly. This negative effect was also extended to fingerling traders and hatchery operators where the ex-hatchery price for grouper fingerlings reduced by 25% (Sim *et al.*, 2003).

Niche market products such as groupers provide handsome returns to

farmers and traders in the region under normal conditions. In the long term the sustainability of the market is not only dependent on technical breakthroughs and technology for better farming, but it is also significantly influenced by the economic conditions of the consuming markets, which in the case of grouper are predominantly Hong Kong and China. Extraordinary events such as terrorist attacks and disease outbreaks also play a vital role in indirectly affecting the demand for live groupers. It is of particular importance for farmers in the region to look at local markets rather than focusing only on export markets to avert such situations. Undoubtedly prices paid by Hong Kong and Chinese buyers are higher, but the risks involved are also greater. A stable domestic market can absorb some of the farmed production, reducing the risk of exposure to extraordinary events such as the SARS outbreak. A stable domestic market is particularly important to small-scale farmers or farmers who rely on groupers as their main species or income generating activity as it provides a buffer against financial turmoil from such events.

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Table 7: Visitor arrivals to Hong Kong from 1999 to 2004.

Year	Visitor Arrivals	Growth
1999	11,328,272	+11.5%
2000	13,059,477	+15.3%
2001	13,725,332	+5.1%
2002	16,566,382	+20.7%
2003	15,536,839	-6.2%
2004	21,810,630	40.4%

Source: Tourism Commission, Economic Development and Labour Bureau. The Government of the Hong Kong Special Administrative Region (http://www.tourism.gov.hk/english/statistics/statistics_perform.html).

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Present status of hatchery technology for cobia *Rachycentron canadum* in Vietnam

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In Vietnam, cobia is gaining attention as a candidate for mariculture because of its rapid growth rate and succulent flesh. Products made from cobia are gaining popularity in Vietnamese markets and are regarded as a potential competitor for salmon on the international market.

Research on artificial seed production of cobia commenced in 1998 at the Research Institute of Marine Products (RIMP) hatchery at Cat-ba (Haiphong Province) under a research program for marine finfish hatchery production. Since 2000, cobia production research has been concentrated at the Research Institute for Aquaculture No. 1 (RIA 1) marine hatcheries at Cat-ba (Haiphong Province) and at Cua-hoi (Nghi An Province) with financial support from the Vietnamese government and SUMA (DANIDA) and NORAD. This research program has been very successful, resulting in the first successful production of about 12,000 fingerlings at the Cat-ba hatchery in 2001 and about 20,000 cobia fingerlings at the Cua-hoi hatchery in 2002. Since then, the RIA 1 hatcheries have regularly produced 50,000 cobia fingerlings annually to support industry development and supply grow-out activities.

The Cua-hoi hatchery was established early in 2002 as a new hatchery for marine aquaculture belonging to the Aquaculture Research Sub-Institute for North Central Vietnam (ARSINC, under RIA1). At Cua-hoi, marine larval production is mainly based on intensive larval rearing techniques using recirculation systems. Soon after the Cua-hoi hatchery opened, a research program on production of some marine finfish species commenced with financial support from NORAD and the Government of Vietnam. One of the objectives of the research program is to develop appropriate hatchery techniques to improve growth and survival of cobia under the climatic conditions of the North Central



Region. After three years of operation, a primary protocol for intensive hatchery production of cobia has been established. RIA 1 researchers now are investigating options to simplify the hatchery production techniques and to improve larval survival, especially during early larval development.

Broodstock management and spawning performance

Cobia broodstock are stocked at densities of less than 5 kg/m³ in marine cages. Cobia may spawn when fish reach two years old and a size of more than 12 kg. Before the breeding season, fish are fed with high quality 'trash' fish supplemented with squid liver oil and vitamins to improve fecundity and egg quality. Gonadal maturation is evaluated by cannulation one month before the breeding season. The eggs and milt can also be used for broodstock screening, e.g. testing for viral nervous necrosis.

When the oocytes reach more than 0.8mm in diameter, the broodstock are transferred from the cages to the breeding tanks in the hatchery. In captivity, cobia can spawn naturally or can be artificially induced through injection with LHRHa at a dosage of 20 microgram/kg (females). Male cobia are injected at half the dose rate of females.

The sex ratio (M:F) spawning should be greater than 1:1 to ensure adequate fertilisation of the eggs. Fish normally spawn 12–36 hours after hormone injection.

The spawned eggs are typically 1.29 ± 0.042 mm in diameter, and are pelagic and transparent with a single oil drop. After spawning, eggs are collected using 0.5mm nylon mesh, counted and checked for fertilization, then incubated in 500L tanks. The eggs hatch after about 24 hours at 27°C. The newly hatched larvae are usually around 3.31 ± 0.1 mm, and are transferred directly from the incubation tanks to the larval rearing tanks as soon as they have hatched. The larvae can be stocked at an initial density of 30–70 individuals per litre without any significant effects on growth and survival rate for the first rearing period. The results of breeding performance in 2005 at ARSINC are summarized in Table 1.

The spawning season for cobia occurs from April to July and normally peaks in May when seawater temperature is around 27–28°C. The Cat-ba hatchery has recorded some maturation and spawning during October – November 2004 but larval rearing was not successful at that time. Each female can spawn several times during breeding season. As the spawning season

progresses, egg quantity and quality (fertilization and hatching rates) generally decline.

Larval rearing

The larval rearing techniques used for cobia in Vietnam are based on two main rearing methods: namely semi-intensive and intensive. For the semi-intensive method, cobia larvae are reared using rotifers and/or nauplii of copepods as live feeds for the first feeding stage and they are then fed adult copepods harvested from shrimp ponds. Formulated diets are introduced from around day 18–20. This method is simple and can provide considerable seed production for grow-out. However, the survival rate is relatively low, below 5%. The copepods collected from the wild may also bring parasites that contribute to mortality in the later rearing stage. This semi-intensive method is mainly conducted at Hai-phong and Quang-ninh where brackishwater ponds are available for copepod collection.

The intensive rearing method is the system used in modern hatcheries where the live feed production and most environment factors can be managed. At ARSINC, cobia larvae are reared in 3000L and 6000L cylindro-conical tanks. These rearing systems utilise biofilters to maintain stable environmental conditions. The larval rearing can be divided into a live prey feeding stage and a nursing stage after the larvae have been successfully weaned to formulated diets.

The live prey feeding stage starts at day 2 or day 3 (depending on water temperature) when the mouths of the larvae open; at this time the larvae are usually around 4.42 ± 0.18 mm TL. This stage normally continues for about three weeks and ends when the larvae are ready to take formulated diets. As soon as the mouths of the larvae open,

the marine alga *Tetraselmis* sp. and *Isocrysis galbana* and HUFA-enriched rotifers are introduced at a density of $20\text{--}30 \times 10^3$ cells/ml and 7–10 individuals/ml respectively. The HUFA-enriched *Artemia* nauplii are introduced from day 8 at a density of 0.5–3 individuals/ml. The period of overlap when co-feeding both rotifers and *Artemia* nauplii should be 4 to 5 days and the live feed supplementation to the cultures should increase as feed consumption increases. The survival rate of live prey feeding period is still quite low (around 30%) and variable. Mortality peaks normally occur after first feeding stage and at metamorphosis.

The weaning diets can be introduced from around day 18 using NRD 2/3 (an INVE product) or Bio-optima 0.2mm (Denmark). The formulated diets should be introduced to the culture tanks before feeding *Artemia*. It normally takes about one week for the larvae to fully wean to the formulated diets. Initially, particle sizes of 0.2mm are fed, and then larger particle sizes are fed according to fish growth. Some recent experiments implemented for a period of 15 days during the weaning stage revealed that reducing larval density from 4 individuals/L to 1 individual/L could increase survival rate

from 38.4% to 59.7% respectively. In addition, increasing feeding frequency can also increase survival rate.

Cobia are carnivorous and become very aggressive at metamorphosis. This contributes to reduced survival during larval rearing. The mortality due to cannibalism can be reduced by grading very frequently and stocking different grades in separate tanks. The grading procedure needs to be started as soon as the larvae show signs of cannibalism, and continued until the fish are ready to stock in the sea cages for grow-out.

After 45 days nursing, cobia may reach around 15cm TL; during this time they are fed pellet diets. The fish then can be transferred to small sea cages for further nursing for about one month before starting grow-out cycle.

Future research: Directions for improvement of artificial seed production

Although the protocol for artificial seed production in Vietnam has been established, the survival rate especially at the early rearing stage is still quite low and variable. The research and development effort for cobia hatchery techniques in recent years has revealed the main issues that need to be addressed to improve survival in the hatchery. Amongst priority topics for research are: improving larval nutrition, reducing mortality due to cannibalism as well as due to stress during transportation, and genetic selection.

Broodstock nutrition improvement is an important research area to improve egg and larval quality. The effect of HUFA level as well as vitamin E supplementation on egg and larval quality



Table 1. Record of cobia breeding performance at ARSINC in 2005.

Parameters	Value
Water temperature (°C)	27.6 – 30.5
Salinity (ppt)	34 – 35
Male : female ratio (mean ± SD)	1.8 ± 0.6
Successful spawning rate (mean ± SD)	0.63 ± 0.4
Fecundity (spawned egg/kg female) (mean ± SD)	139,000 ± 42,400
Fertilization rate (mean ± SD)	0.51% ± 0.4
Hatching rate (mean ± SD)	0.35% ± 0.2

needs to be clarified and evaluated. It will also be important to investigate how to extend the breeding season to provide seed throughout the year. Additional research is necessary to establish seed production techniques during wintertime when grow-out activities normally have to terminate due to bad weather conditions.

The nutrition for larvae at different development stages is very significant because cobia larvae grow rapidly. Improving larval nutrition to support development will increase survival rate, reduce production costs as well as shorten the rearing period. In this area, the requirement of HUFA level with appropriate ratios of DHA, EPA and ARA

should be determined to develop appropriate formulated diets. In order to simplify the rearing protocol, research should focus on replacing the live prey feeding period as soon as possible with appropriate larval and weaning diets.

Report on grouper hatchery training course in Indonesia

Reporter: Nguyen Quoc Thai

Diversification of species is one way in which poor people involved in coastal aquaculture can reduce their vulnerability to external factors such as the global price slump and anti-dumping tariffs facing the shrimp industry. Diversification can help farmers to develop a sustainable livelihood, and in some circumstances to reduce the level of investment required and general level of risk.

Marine fish culture has been practiced by Vietnamese farmers for a long time although the techniques employed have largely been dependent on wild seed. Normal practice has been to buy grouper fingerlings from fishing boats and to fatten them in a cage or pond before resale. Some farmers catch their own grouper fingerling from the wild and culture them at a low density so that the production is low and not well targeted to market demand. A few years ago grouper farming began to expand as an industry, creating increased demand for wild grouper fingerlings and a shortage of supply. To ensure that farms can get an adequate supply of high quality seed from a sustainable source, it is necessary to implement grouper hatchery technology in Vietnam and to develop a seed supply chain that will service the industry.

To realize the huge demand for grouper fingerlings, as a shrimp hatchery owner, I had planned to convert part of my hatchery to grouper production. The production duration is longer but I can also make a better profit while assisting farmers in my area to improve their own businesses. Through the NACA website, I heard that a training course on grouper hatchery technology would be organized in Indonesia from 19 May to 9 June and so I decided to attend.

My expectations, prior to attending the course were that I would gain:

- An overview of marine finfish production in ASEAN countries and global trends.
- Knowledge of grouper hatchery technology and techniques for managing broodstock, breeding and growout from larviculture to fingerling stage.
- Develop a good relationship with other people working in marine finfish hatchery technology in the region, including scientists, researchers, technical workers and other grouper fingerling suppliers.

The course covered many subjects that I found interesting. Of particular interest to me were the sessions on the status of mariculture in Indonesia,

larviculture and nursery of grouper, live feed production, disease and fish health management in the hatchery, and the discussions with other farmers doing business on grouper hatchery and nursery operations.

Now that I have completed the course I have plans to convert part of my shrimp hatchery to a grouper hatchery, so that I will be able to produce simultaneous crops of grouper and shrimp. I want to produce grouper at two different sizes – fry (2-3cm) and fingerling (7-8cm). I also plan to help transfer knowledge of grouper hatchery technology to other shrimp hatchery operators that I know.

I have begun the first steps towards these goals already. I am currently involved in nursing seabass fry for delivery to farms in Nghe An province, collecting grouper fry from the wild for nursery (until I get the hatchery side going), and I am looking for a co-funding partner to help establish a live feed culture system.

I would like to thanks to organizers, sponsors, lectures and assistant who were help me attend the course.

Collaborating organizations



Biosecured and improved penaeid shrimp (*Penaeus monodon*) production through organic nursery raceway system in India

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Shrimp farming is a highly profitable and a fast growing sector with an enormous scope to increase foreign exchange and generate employment in a developing country like India. However shrimp farming needs to be conducted in a way that is socially acceptable, economically viable, technically appropriate and environmentally sound.

Brackish water aquaculture in India is synonymous with shrimp farming, with the tiger shrimp *Penaeus monodon* the mainstay of production. Unfortunately the shrimp farming sector currently faces some serious disease problems and environmental issues, impacting on production levels and creating an uncertain and unpre-

dictable harvest. Shrimp production in raceway tanks with limited or zero water exchange grow out ponds is an encouraging alternative method to minimize crop losses and environmental degradation. Introducing a nursery phase to shrimp culture systems can increase control over stock inventories, water quality and feed management¹. It also allows shrimp to be stocked at a larger and hardier size and potentially to increase the number of crops per year as a shorter period is needed to reach marketable size^{2,3,4}. The survival of nursery systems can be relatively high (85–95%) with higher anticipated profit^{4,5,6,7,8}. Used appropriately, nursery systems can also reduce the spread of

diseases as post larvae can be effectively quarantined during the nursery phase. Thus a significant improvement in yields has been reported from white spot infected areas in Ecuador when intensive nursery facilities have been used rather than direct stocking^{9,10,11}. Farms with intensive nursery facilities can also stock and store PLs at high density to reduce pressure on limited hatchery supplies¹.

This article describes raceway systems prototyped at Fisheries College and Research Institute, Thoothukudi, India and an advanced management strategy developed to increase juvenile shrimp survival and production for the initial 50 days (the crucial phase of shrimp culture) in tropical Indian conditions.

Biosecure nursery raceway system

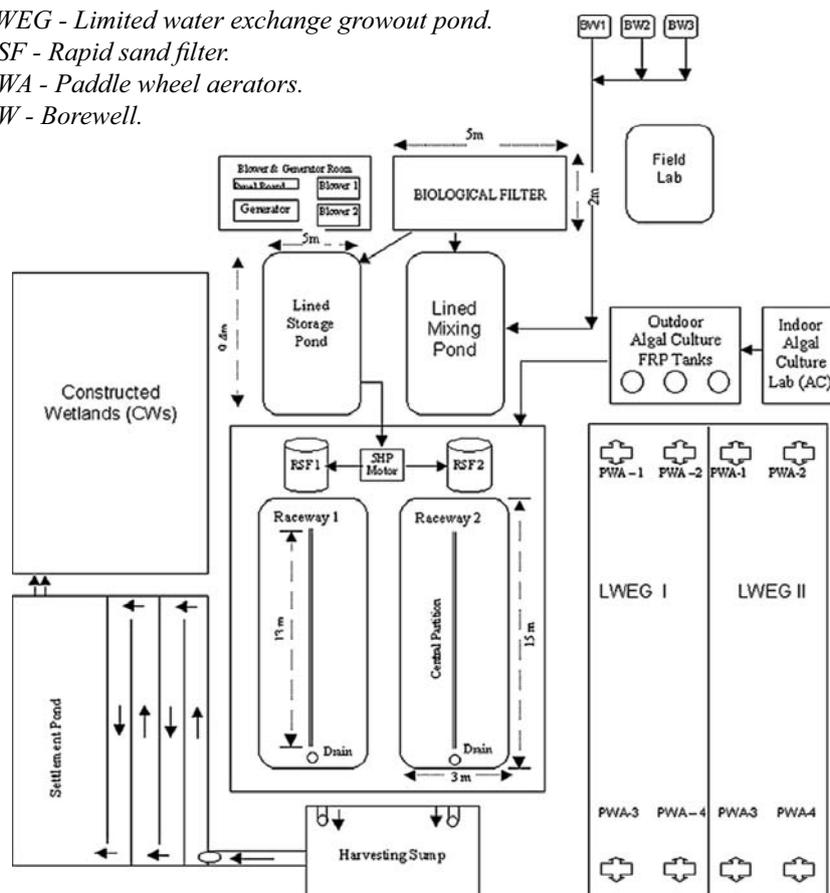
This nursery raceway system was suitably modified and designed based on the concepts and management developed by the Texas Agricultural Experiment Station, Shrimp Mariculture Research Facility^{12,13}. Two raceways (dimensions 15m x 3m x 1 m, 45m³ volume, 45m² surface area) were used in this study. The raceways were filled to 0.75 m (operating volume of 30m³) with a free board of 0.20 – 0.25m. The raceways were constructed by excavating earth and forming dykes, and after sufficient consolidation, fabricated pre-cast cement slabs (50mm thickness) were fixed on the bottom and sides. The raceways were lined with 700 GSM nylon fabric sheet and designed with a 0.5% slope towards the drain at the end, where the drains are located. The outlets of raceway tanks fed into a harvesting tank (3m x 1.5m x 2.1m) and from which the used water was sent to constructed wetlands for treatment. Each raceway was provided with a 13m long and 1m deep central parti-

LWEG - Limited water exchange growout pond.

RSF - Rapid sand filter.

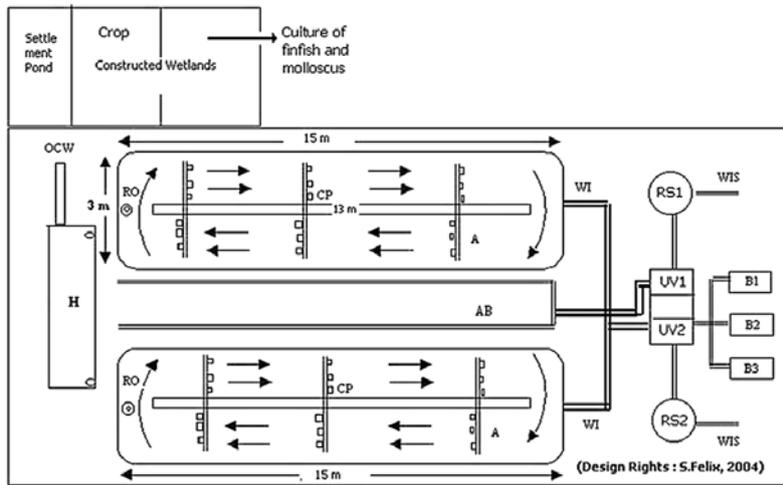
PWA - Paddle wheel aerators.

BW - Borewell.



DESIGN LAYOUT OF RACEWAY FARM COMPLEX (PROTOTYPE)

Layout of raceway system.



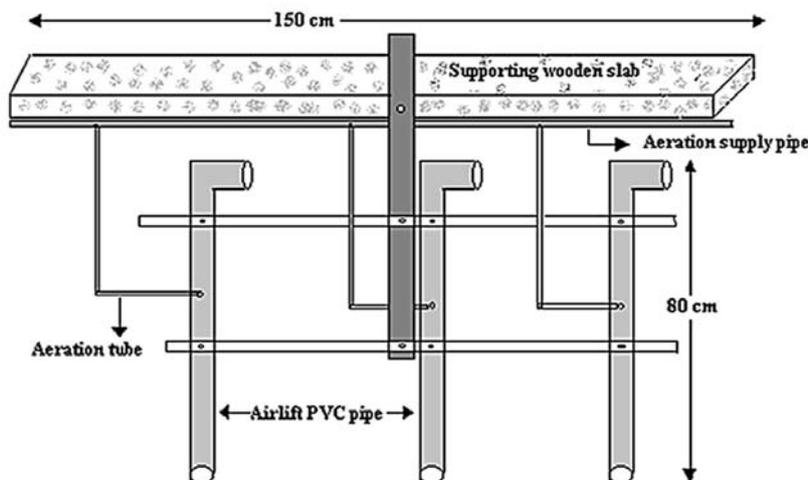
tion, which was made up of waterproof marine plywood of 20mm thickness, hung vertically with the support of five cross-wooden beams connected by stainless steel bolts. The height of the central partition can be adjusted by changing the position of the bolts on the beams. Each raceway was provided with six airlift pumps, three on each side of the central partition, supplied by two 5HP twin lobe air blowers, operated alternately every three hours. One set of airlift pumps contained three 50 mm airlifts of 80cm height. The system contained an alarm to warn of power failures and a 15 KVA backup generator was installed to ensure that blowers and paddle wheels could be maintained in event of a blackout. Water was drawn from three different subsoil bore wells (as access to sea water was not possible at this site) with different salinities.

Water was therefore pumped to a mixing pond in order to ensure consistent quality, before being passed through a biological, rapid sand / activated carbon filter and UV sterilizer system for supply to the raceways. The raceway tanks were situated under a 'green house' roof made from transparent and non-transparent (alternatively placed) FRP roofing for protection and to control of light penetration. The sides were covered with 75% green shade net to avoid the entry of pests and predators.

Rearing shrimp in the nursery

The raceways were cleaned and washed with chlorinated water prior to filling. Culture water was also treated with liquid chlorine (10 ppm active chlorine). The raceways were fertilized

with fermented product and the culture water inoculated with monoculture diatom, *Chaetoceros* sp. Raceways were stocked with fifteen-day-old postlarvae certified as free from whitespot syndrome virus (WSSV) purchased from a commercial hatchery. The two raceways were stocked at the rate of 1000 PL/m³ (666 PL/m²) and 2000 PL/m³ (1333 PL/m²) raceways. Shrimp were fed with dried crumbled and pelleted commercial feed contained 38% crude protein, 5% fat, 12% moisture and 4% ash. Shrimp were fed five times a day with 60% of the daily ration given at night. The daily ration was adjusted based on the estimated biomass and observed feeding behavior. Raceways were maintained with no water exchange for first 15 days. From day 16 until harvest, the accumulated solid wastes were removed from the bottom of the raceway tanks at weekly intervals. The loss of water in raceways by evaporation and through the process of metabolite removal was compensated by adding filtered and UV sterilized water. The algal cell concentration was observed weekly and indoor/outdoor mass cultured algae (*Chaetoceros* sp.) was inoculated to the raceways at regular intervals. A specific fermented product was also added to the raceways to sustain the beneficial microbial population in the raceways and to maintain them as a heterotrophic system. The combination of pure algae and fermented product helped to control ammonia and other harmful nitrogenous pollutants in the raceways within the acceptable limits. Water quality and physio-chemical parameters viz. temperature, pH, dissolved oxygen, transparency, algal composition, etc. were measured daily and ammonia, nitrite and total microbial load were assessed weekly. The growth rate of shrimp was measured at weekly intervals by collecting a random sample. After the rearing period of 50 days both the raceways were harvested in live and they were stocked in the limited water exchange (LDPE lined) growout ponds. While most of the shrimps could be harvested by scoop net from the raceways the remainder were harvested at the end of the nursery period when the raceways were completely drained. At the end of the experiment production,



Longitudinal section through airlift and structural support.

Table 1. Water quality parameters* recorded in raceways (on daily basis).

Weeks	pH		DO (ml/l) at dawn		Transparency (cm)	
	R1	R2	R1	R2	R1	R2
1	8.62 ± 0.063	8.48 ± 0.085	5.13 ± 0.18	5.18 ± 0.21	35 ± 3.4	34 ± 4.35
2	8.55 ± 0.037	8.42 ± 0.038	4.68 ± 0.31	4.98 ± 0.84	31.5 ± 1.9	28.5 ± 1.0
3	8.57 ± 0.050	8.30 ± 0.082	4.96 ± 0.42	5.296 ± 0.49	26 ± 4.2	25 ± 3.4
4	8.52 ± 0.050	8.18 ± 0.126	5.51 ± 0.11	5.52 ± 0.21	22 ± 1.25	23 ± 1.9
5	8.05 ± 0.057	7.90 ± 0.082	5.02 ± 0.29	5.18 ± 0.21	25.5 ± 2.08	25 ± 0.5
6	8.33 ± 0.049	8.12 ± 0.150	5.35 ± 0.36	5.35 ± 0.32	29 ± 1.99	29 ± 0.96
7	8.30 ± 0.017	8.15 ± 0.015	5.96 ± 0.66	5.85 ± 0.82	32 ± 3.3	30 ± 1.5

R1 = Raceway 1; R2 = Raceway 2; * Daily parameters represented for weeks.

Table 2. Parameters recorded in raceways (on weekly basis).

Weeks	Ammonia (mg/L)		Nitrite (mg/L)		Algal cell count (cells/mL)		Microbial Load (cfu/mL)	
	R 1	R 2	R 1	R 2	R 1	R 2	R 1	R 2
1	0.071	0.066	0.67	0.07	5.2 x 10 ⁴	5.4 x 10 ⁴	13.5 x 10 ³	13.7 x 10 ³
2	0.064	0.069	0.78	0.078	5.75 x 10 ⁴	7.5 x 10 ⁴	7.8 x 10 ³	5.4 x 10 ³
3	0.066	0.065	0.49	0.39	5.0 x 10 ⁴	5.41 x 10 ⁴	13.6 x 10 ³	15.1 x 10 ³
4	0.25	0.28	0.15	1.5	5.45 x 10 ⁴	5.3 x 10 ⁴	7.75 x 10 ³	13.2 x 10 ³
5	0.10	0.14	0.4	1.35	6.3 x 10 ⁴	6.7 x 10 ⁴	22.1 x 10 ³	22.3 x 10 ³
6	0.112	0.22	0.36	0.09	4.9 x 10 ⁴	6.2 x 10 ⁴	28.3 x 10 ³	28.4 x 10 ³
7	0.075	0.069	0.093	0.49	5.0 x 10 ⁴	6.5 x 10 ⁴	21.8 x 10 ³	14.8 x 10 ³

R1 = Raceway 1; R2 = Raceway 2.

Table 3: Results of Raceway Trial using *P. monodon*.

Raceway	Stocking density	Mean initial weight (g)	DOC	Biomass (kg/m ³)	Harvest (kg)	Survival
RW 1	1,000 / m ³	0.001	45	0.718	21.53	82%
RW 2	2,000 / m ³	0.001	45	0.428	12.83	52%

survival rate, food conversion ratio (FCR) and other bio-growth parameters were estimated.

Outcome

Of the two stocking densities 1,000 and 2,000/m³ attempted in the raceways, the stocking density of 1,000/m³ attained the maximum biomass yield of 0.72 kg/m³, which was 67% higher than the biomass (0.43 kg/m³) obtained from the raceway with the stocking density of 2,000/m³. Further, the 1,000/m³ stocking density also recorded the highest survival rate of 82% compared to 52% in the other raceway system. Similar nursery raceway trials carried out by using *P. vannamei* undertaken by Bart Ried and Arnold¹⁴ recorded a survival rate of 48% and 82% for 2,132/m³ and 970/m³ stocking densities, respectively. The raceway trials undertaken for the first time in India for *P. monodon* confirmed that the stocking density of 1,000/m³ in nursery raceway systems is more appropriate under the conditions of these trials, although further work is

required to assess the optimum stocking density. The results obtained from raceway shrimp trial are given in table 3.

In recent years, many improvements have been made in bio-filtration and water sterilization that can increase the carrying capacity and production potential of recirculating systems by improving water quality parameters. Heterotrophic microbial-based management has a major role in disease prevention, stress reduction and in maintaining water quality, in particular the conversion of nitrogenous metabolites into less toxic forms and biofilms play a role in absorbing suspended particles.

Indoor biosecure raceway-based shrimp production is gaining popularity in many western countries and also in China's southwestern Guangxi provinces, as farmers seek alternatives to traditional outdoor pond culture. Although, operating costs of indoor biosecure culture systems are relatively high, their eco-friendly nature and improved capacity to manage disease risk is leading shrimp farmers all over the world

to investigate this approach¹⁵. High stocking density, higher yields and lower disease risk coupled with a more predictable harvest from indoor tanks can compensate for the greater investment required. Indoor biosecure shrimp production also requires less land area compared to traditional farming methods for raising tiger shrimp, and is well suited to conducting the initial nursery phase if shrimp are shifted to limited water exchange outdoor tanks / ponds after 45-50 days of culture to attain faster growth in a short period.

Another potential benefit is that raceways could be partitioned into nursery raceways and growout raceways and managed separately to attain faster growth and higher yields¹⁶. In nursery raceways stocking densities as high as 4,000 to 7,800 PL/m² were attempted successfully in Texas, USA¹⁷ in 40 to 50 days DOC for *P. vannamei*. The system does not require the use of any chemicals, drugs or additional inputs and the entire crop is raised according to 'organic farming' concepts. It has the potential to go a long

way towards the vision of developing a biosecure shrimp culture system at a reasonably cost-effective budget for tropical countries like India.

Acknowledgement

The authors wish to acknowledge the assistance of the Department of Biotechnology, New Delhi who funded the research project "Prototyping of raceway based third generation shrimp production technology" to implement this innovative culture system. Dr. Samocha, Texas A&M University provided valuable technical advice, which is greatly appreciated. The AHRDP, Govt. of India who funded (Dr.S.Felix) for the training at Texas A&M University is acknowledged.

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Management of monogenean parasites in brackishwater finfish

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Monogenean trematodes (flukes) are a group of parasites best described as a kind of flatworm. They are commonly found on the gills, skin and fins of fishes, hence the common name of 'skin flukes' or 'gill flukes'. More than 100 families of monogenean trematodes infect fishes at all salinity levels and temperatures. This article describes monogenean parasites of farmed brack-

ishwater fishes, viz., sea bass, grouper, mullet and pearl spot, along with strategies for their management.

The parasites

Monogeneans are external parasites (ectoparasites) that complete their entire life cycle on a single host. The adults vary in size from less than 1 mm

to around 5 mm in length. They attach to the host with a specially adapted structure on the posterior end of the parasite (haptor or opisthaptor). This organ has hooks that allow the parasite to attach firmly to the host fish while feeding, creating a serious threat to fish health, particularly in aquaculture systems where a high density of host fish may allow them to proliferate.

Excessive parasite loads are generally associated with crowding, inadequate sanitation and deterioration of water quality (Snieszko, 1974), and can result in mass mortalities in cultured fish, even in large fish such as sea bass. Although monogeneans are commonly found on wild fish, they are rarely a direct cause of disease or death in free-ranging populations. Some of the most common monogenetic trematodes of brackishwater fishes include: *Gyrodactylus* spp., *Dactylogyrus* spp., *Diplectanum* spp. and *Benedenia* spp.

***Gyrodactylus* spp.**

The adult worms are typically less than 1 mm in length, with bifid anterior end and opisthaptor with 16 marginal hooks and 2 large anchors or hamuli. Eyespots are absent. They are most frequently found on the skin and less commonly on the gills. They infect a variety of fish species including economically important fishes such as sea bass, grouper, mullet and pearl spot.

Members of this genus are of particular importance in aquaculture where large populations of fish are confined in small volumes of water (ponds or cages), forcing more frequent contact between fish than would normally occur in a natural habitat. Rapid increases in populations of these flatworms can occur in such environments. One of the most interesting features of these parasites, and which also makes them so devastating, are their unusual reproductive cycle. Unlike other monogeneans, which produce eggs, *Gyrodactylus* spp. are live-bearing. The larvae develop into a functional preadult internally within the parent and already have their own larvae developing internally before birth. These in turn also have larvae developing internally and so on – such that a single adult can contain four generations of larvae developing internally! This is known as *polyembryony*, the result of which produces four individuals from a single fertilisation, giving the parasites the capacity for an explosive growth in numbers. When fish are living closely together, as in a cage or pond environment, it is easy for the adult worms to move from one fish to another thus spreading the infection. The life cycle of these parasites can occur entirely on a host, but they can also

survive for short periods in the absence of a host.

***Dactylogyrus* spp.**

These parasites are typically between 0.2 to 0.5 mm in length, reaching a maximum length of 2.0 mm. They have a scalloped head, seven pairs of marginal hooks and usually one pair of median hooks on the opisthaptor. The dactylogyrids have two to four pigmented spots known as “eyes” or “eye spots” on the forward quarter of the body. All dactylogyrids are egg layers.

Dactylogyrus spp. occur in a wide variety of fishes including sea bass, grouper, mullet and pearl spot of all sizes. Seabass, mullet and pearl spot fry are particularly susceptible, succumbing with high mortality. Gill hyperplasia (proliferation of cells in the gill tissue, causing the filaments to thicken) is seen in heavy infections and results in serious deformation of gill lamellae. Heavily infected fish may also exhibit blood changes that included low hematocrit values and depletion of hemoglobin (anaemia).

***Diplectanum* spp.**

The adults are elongate, approximately 1 mm in length with a well delimited opisthaptor armed with 14 marginal hooks, 2 pair of anchors, 3 transverse bars, and a dorsal and a ventral auxiliary attachment organ known as a squamodisc. Two pairs of eyes are present. The eggs are elongate and pear shaped with long thread-like attachment mechanisms. Lower temperatures have been found to be suitable for egg development of these parasites.

Diplectanum spp. have been recorded mainly in sea bass and groupers. These parasites only infect the gills of sea bass, which appear off-color with a thick mucous layer and occasional hemorrhagic spots. Heavy parasitic infestations interfere with respiration and cause mortality. Infected fish often show respiratory abnormalities and swim near the water surface and cause large-scale mortality even in brood-stock fishes (Rajendran *et al.*, 2000).

***Benedenia* spp.**

Benedenia spp. are relatively large parasites, flattened in shape with elongated body measuring up to 3.5 mm with 2 pairs of eye spots. The rear end is armed with disc like opisthaptor with hooks. The forward end possesses one pair of suckers.

Monogenean parasites belonging to *Benedenia* spp. are an important problem often causing large-scale mortality of fishes maintained in captivity. The parasites have been found to infest both the gills and skin of sea bass and groupers. Fish with severe infections have small focal hemorrhages on the body, which often result in secondary bacterial infections (Jithendran *et al.*, 2005).



Benedenia spp., a common parasite (Photo L. Tak Seng).

Clinical signs and effects

Most monogeneans flatworms are browsers, moving about the body surfaces, and feeding on skin mucus and gill debris. Most species are host- and site-specific, requiring only one host to complete an entire life cycle. In fact, some adults will remain permanently attached to a single site on the host. Fishes that are infested with skin-inhabiting flukes become lethargic, swim

near the surface, seek the sides of the pond and their appetite dwindles. They may be seen rubbing the bottom or sides of the holding facility (flashing). The skin where the flukes are attached show areas of scale loss. Heavy gill infestations result in respiratory disease. Gills may be swollen and pale, respiration rate may be increased, and fish will be less tolerant to low oxygen conditions. "Piping", gulping air at the water surface, may be observed in severe respiratory distress. In most cases infestations are not severe enough to cause epidemics. However, under intensive culture and adverse environmental conditions that favours the parasite and cause stress to fish may result in mass mortality. It is well recognized that a few unhealthy / stressed animals are more susceptible to infection and harbour majority of the parasites. Secondary infection by bacteria and fungi are common on tissue that has been damaged by monogeneans.

Transmission

Transmission of monogenean flukes from fish to fish is primarily by direct contact, as most monogeneans tend to have direct life cycles and hence can contribute to population explosions in aquaculture systems, resulting in clinical disease (SEAFDEC, 2001). Oviparous monogeneans (i.e., Dactylogyridae) release eggs into the water, which on hatching, release ciliated free swimming larvae that seek out a fresh host on which to settle and mature. Viviparous monogeneans (i.e., Gyrodactylidae) release live larvae, which may attach to the same host as the parent or be carried by water to another host. There are two common genera of flukes, *Gyrodactylus* and *Dactylogyrus*, which differ markedly in their reproductive strategies as well as their preferred attachment sites on host fish. *Gyrodactylus* are generally found on the body and fins of fish. Each individual parasite has both male and female reproductive organs. Adult parasites carry a fully developed embryo (identical to the adult) which in turn, carry young of the next generation. Therefore, each individual parasite may represent several generations. This reproductive strategy allows populations of *Gyrodactylus* to multiply very quickly, particularly in a

closed system where water exchange is minimal. Members of the genus *Dactylogyrus* prefer to attach to gills of host fish. Unlike *Gyrodactylus*, parasites in the genus *Dactylogyrus* attach to gills and are egg layers. Gill flukes are often favoured with a high degree of protection due to the gill hyperplasia and increased mucous secretion. Further, the eggs can be resilient to chemical treatment, which make the use of multiple treatments appropriate to control this group of organisms. When the eggs hatch, free-swimming larvae emerge which are ciliated and which are carried to a new host by water currents as well as by their own movement. The time required for maturation of *Dactylogyrus* from eggs to adult is temperature dependent. In tropical water only a few days are required for completion of the life cycle, whereas at cooler temperatures, generation time is extended to five or six months.

Diagnosis and management

Disease control is a vital component of a broodstock programme since a single outbreak of a parasite or associated secondary infections can wipe out an entire stock. The brood stock manager's best strategy is coupling prevention and early detection by maintaining the fish under optimal environmental conditions. The best way to manage monogeneans is to avoid introducing parasites to an established system. This can be done by dipping fish prior to placing them into the system, and by following a quarantine protocol whenever feasible. If quarantine is not possible, a simple way to minimize introduction of monogeneans, as well as other external parasites, is to dip fish in fresh or salt water, depending on species. Salt-water fish can be dipped in fresh water, which will eliminate many single-celled external parasites, and freshwater fish can be dipped in seawater to accomplish the same goal. This practice will not completely eliminate the risk of introducing parasites to an established tank or system, but it does help minimize the numbers that are brought in.

Ideally, fish should be quarantined for at least three weeks prior to being placed into a new system. While in quarantine, a definite diagnosis can only be made via a skin scrape or gill

biopsy. Any parasites that are identified using biopsy techniques can then be specifically treated and eliminated. If biopsies cannot be done, then prophylactic treatment with a broad-spectrum parasiticide, such as formalin or potassium permanganate, should be carried out. In severe cases it is important to do a follow up at the end of the treatment to see how effective it has been. A quarantine system should be very simple so that fish are readily accessible for observation and handling, water can be easily changed, and treatments readily administered.

Treatment of monogeneans is usually not satisfactory unless the primary cause of increased fluke populations is found and alleviated. Further, knowledge of the life cycle is critical to the understanding of parasite pathology, epizootiology and to the management and control of parasitic diseases in aquaculture systems. Fish that are very sick do not tolerate formalin well and all fish should be carefully watched during chemical administration (Kabata, 1985). Short bath treatment (30-60 min) with 100-200 ppm formalin or hydrogen peroxide (1000 ppm) under strong aeration has been found to be effective for control of most of the monogenean parasites in brackish-water systems. If adverse reactions are observed, fish should be removed from the treatment tank at once and placed in clean water.

Potassium permanganate is also effective against monogeneans, and is the treatment of choice if bacteria or fungi are invading damaged tissues. Potassium permanganate can be administered as a prolonged bath (24 hrs) at a concentration of 2 mg/L or as a short-term bath at a concentration of 10 mg/L. Again, fish must be observed carefully while they are in contact with the chemical and they should be removed at once if they appear to be distressed.

Freshwater dips should be given to saltwater fish prior to placing them into a new system. Freshwater baths are effective in dislodging the parasites from the fish. A salinity shock with 3 - 7 % sodium chloride dip for 3 minutes also kills *Dactylogyrus* and *Gyrodactylus* spp. This is very helpful in preventing the initial introduction of monogeneans,

however complete elimination of the parasites from the system is difficult.

Effective management of farms can minimise parasite numbers and is an alternative to use to chemotherapeutants. These problems are essentially a decision regarding management and control of parasitic diseases accommodating the ecological and economic factors.

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Vembanad Lake: A potential spawner bank of the giant freshwater prawn *Macrobrachium rosenbergii* on the southwest coast of India

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Macrobrachium rosenbergii broodstock of more than 100g, collected from Vembanad lake.

In India, seed of the giant freshwater prawn *Macrobrachium rosenbergii* (often known locally as scampi) is produced with variable levels of success as no specific criteria are followed to evaluate broodstock quality for hatchery seed production. Moreover, commercial hatcheries obtain brooders either from wild stock¹ or from grow-out ponds². The soaring demand for seed cannot be fully met from the wild. Moreover, wild stocks of *M. rosenbergii* have declined rapidly in recent years due to over exploitation³, habitat loss and increased pollution particularly in

southeast Asia⁴. This has been documented from countries including Bangladesh, India, Indonesia, Malaysia, the Philippines and Thailand⁵. These days, commercial farms are the main supply source of broodstock for hatcheries. Inevitably, the stocks used by commercial farms are experiencing a decline in productivity due to inbreeding depression as hatchery-produced siblings are 'recycled' as broodstock over multiple generations⁵. Farm reared females also attain sexual maturity much earlier than their wild counterparts⁶; the size at first maturity is also smaller and character-

ized by relatively poor fecundity and larval viability. These issues generally result in a reduction in the mean size of cultured scampi in subsequent generations. The recent occurrence of 'white tail disease' in farm reared *M. rosenbergii* is also a major threat to its culture in India. These issues need to be addressed, and over fishing of the wild stock reduced, in order to improve the sustainability of the industry and to lay a foundation for genetic improvement programs of farmed stocks.

Vembanad Lake, situated in Kerala (Lat 9° 28' & 10° 10' N and long 76°

13' & 31' E) is the largest brackish water body on the southwest coast of the Indian peninsula. The lake is approximately 60km in length and covers an area of around 21,050ha¹. It acts as a giant reservoir, protecting against floods and is in itself a major ecological resource. The lake has a unique feature of possessing two different ecosystems, retaining an estuarine condition in the downstream region (the Cochin backwaters) and a freshwater habitat in the upstream regions (Thanneermukkom to Alleppey). In the 1950s and early 1960s giant freshwater prawn were a lucrative component of the fishery in Vembanad Lake and its confluent rivers. As an important component of shrimp exports and earner of foreign exchange for Kerala, it emerged as the most valuable species in the inland waters of the state. However, since the 1980s stocks of the giant freshwater prawn have declined substantially due to various interventions including over fishing⁷. From literature it is known that Vembanad Lake is endowed with commercial-scale capture fisheries for both *Palaemonid* and *Penaeid* shrimp. The *Macrobrachium* fishery itself is one of the major fishery activities with several species present, accounting for about 1.63% of the exploited fishery resources of the lake. The annual yield of different freshwater prawns include: *M. rosenbergii* 39.27 tons, *M. idella* 68.3 tons, *M. scabriculum* 6.78 tons and *M. equidens* 3.34 tons⁸.

Berried females start appearing in the catches in July-August and increase until October-November. The slow moving ovigerous females that become abundant in the lake after August are compelled to undertake a lengthy breeding migration. It has been reported that over 23 tons of berried females are exploited annually from the lake, the highest being in October. Males are predominantly found between January to June and the females are predominant during the period August to December. Females of around 100-150g dominate the catch, representing approximately 44%⁷. Only about 30% of the total spawner stock is thought to successfully reach the breeding grounds.

It is noteworthy that the brooders of Vembanad Lake are characterized by a greater size and higher fecundity

than wild brooders from other areas. Females between 157-258mm and weight of 34.2g-202g have an absolute fecundity ranging from 30,000 to 227,000 eggs⁹. Unfortunately, removal of wild brooders for hatchery operations reduces the supply of wild seed to support the natural population.

Recently it has been realized that wild brooders give much better quality seed. The practice of carelessly selecting broodstock from hatchery populations, often from the same batch, has created vicious cycle of inbreeding, leading to poor quality seed. Vembanad Lake has the potential to provide high-quality broodstock for the industry, until such time as appropriate broodstock management strategies are in place to maintain the genetic integrity of hatchery-reared populations. Restrictions on the fishing of *M. rosenbergii*, at least during breeding season, would enhance and conserve the wild stock. It would also be useful to encourage the construction of hatcheries adjacent to the breeding grounds, where berried females are found, and the establishment of sanctuaries and hatcheries would be a useful step towards the establishment of a broodstock enhancement program¹⁰. Broodstock purchased from the fisherman for seed production should be returned to the waters so as to minimize the impact on the wild stock. Harikrishnan and Kurup¹ have emphasized that the temporal and spatial availability of berried prawns in the lake for establishing berry procurement centers. In this connection, it would be useful for the state government and freshwater prawn fishery authority to take necessary steps to regulate and monitor stock levels and the fishery activity in the lake, particularly during the breeding season, in order to avoid over exploitation of this valuable resource.

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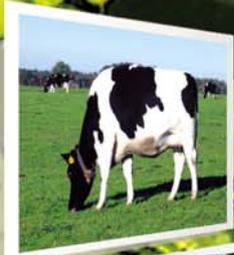
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