

# AQUACULTURE ASIA

Recent developments in Chinese inland aquaculture

Marine finfish market information & development trends

Market analysis of the live reef food fish trade

Reducing feed costs in aquaculture

Seed production of gouramis





# AQUACULTURE ASIA

## Aquaculture Asia

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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## Molecular tools in aquaculture...coming to a website near you

We have a great new publication coming up: A manual on the application of molecular tools in aquaculture and inland fisheries management. The manual has been co-written by NACA's Dr Thuy Nguyen our partners from Kasetsart University, the Thai Department of Fisheries, the Queensland University of Technology and the Food and Agriculture Organization of the United Nations.

The aim of the manual is to provide a comprehensive practical tool for the generation and analysis of genetic data for subsequent application in aquatic resources management, in relation to genetic stock identification in inland fisheries and aquaculture. The material provides a general background on genetics in relation to aquaculture and fisheries resource management, the techniques and relevant methods of data analysis that are commonly used to address questions relating to genetic resource characterisation and population genetic analyses.

The manual includes two 'stand-alone' parts: **Part 1 – Conceptual basis of population genetic approaches** provides a basic foundation on genetics in general, and concepts of population genetics. Issues on the choices of molecular markers and project design are also discussed. **Part 2 – Laboratory Protocols, Data Management and Analysis** provides step-by-step protocols of the most commonly used molecular genetic techniques utilised in population genetics and systematic studies. In addition, a brief discussion and explanation of how these data are managed and analysed is also included.

This manual is expected to enable NACA member country personnel to be trained to undertake molecular genetic studies in their own institutions, and as such is aimed at middle and higher level technical grades. The manual can also provide useful teaching material for specialised advanced level university courses in the region and postgraduate students. The manual has gone through two development/improvement stages. The initial material was tested at a regional workshop and at the second stage feedback from participants was used to improve the contents.

As usual, the manuals will be made available for free download from the NACA website [www.enaca.org](http://www.enaca.org). Keep an eye out for them!

Lastly, just a reminder: The NACA Newsletter will no longer be published as a separate entity as of January 2007. We are rolling the newsletter into the magazine as a separate section, so they will be packaged and distributed together from this point forward. We hope you like it, and the 'new look' that will accompany the 2007 issues.

*Simon Wilkinson*

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# Rural Aquaculture



## Recent developments in Chinese inland aquaculture



*Terraced rice-fish fields in mountainous Zhejiang Province.*

Following the 2nd International Symposium on Cage Aquaculture in Asia in Hangzhou, Zhejiang Province, China in July, I took advantage of a long standing invitation from AIT alumnus, Professor Qingjun Shao, Zhejiang University to show me recent developments in Chinese inland aquaculture. AIT students from China had long commented on my rather dated teaching of Chinese aquaculture based on an assignment I undertook there for NACA through FAO/UNDP in the early 80s. The change in aquaculture over the past 25 years from polyculture systems integrated with crops and livestock to predominantly pellet-fed monoculture of high-value species has been dramatic indeed.

However, we did visit traditional rice/fish culture in mountainous Qingtian County about 300 km south of Hangzhou at the invitation of Ye Minger, Assistant Governor of the County, who also kindly sponsored our visit. I was asked to make a presenta-

tion to local officials of rice/fish culture systems outside China; and to provide an opinion on how to conserve and further develop the local system, albeit based on a very short visit.

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It is documented that local farmers started to raise fish in terraced rice fields in Qingtian County more than 1,200 years ago. The system originated from the practice of irrigating rice fields by gravity from streams during which fish entered and started living in the fields. After a long period of domestication, the current red coloured soft-scaled, common carp evolved. Locally it is not considered to be a variety of common carp but a distinct fish referred to as 'Qingtian field fish'.

Compared to the current farm gate price for normal common carp of Yuan 4-5 (\$0.5-0.6)/kg near Hangzhou, the local fish has a farm gate price of Yuan 30-40 (\$4-5)/kg for live fish. It is also sold dried at Yuan 100 (\$12.5)/kg as overseas Chinese also consider it to



*Close up of fish in a ricefield.*



*A trench in a ricefield.*

be a delicacy; more than 30% of the population of the densely populated County have emigrated abroad to some 29 countries. At least 30 counties within China import it also. Of the carp produced in rice fields, 80-90% is consumed in the County, 10% is sold to neighbouring counties in the province, and the rest is sold abroad.

About 80% of the rice fields in Qingtian County are stocked with the carp, about 100,000 mu (almost 7,000 ha). In the traditional system the carp are bred in a corner of a rice field with the fry directly released into the field, with some on occasion being sold to other farmers. Bamboo shoots or tree branches are placed in the field for the fish to deposit eggs on. The fry are raised to table fish extensively without fertilization or feeding fish, although livestock manure is used as a basal fertilizer for rice before transplantation. Fry survival is low and surviving fish grow slowly, taking 2-3 years to reach table size. The stocking density is not controlled in the traditional system in which the fish production is from 25 up to 40-80 kg/mu (375 to 600-1,200 kg/ha). The value of rice cultivated alone is only Yuan 800 compared to more than Yuan 1,000/mu/year with fish stocked in the rice fields. As land is limited in the mountains (with an average family size of 4-5 people being allocated less than 0.5 mu/person, average farm size is only about 2.0-2.5 mu or 1,300-1,700 m<sup>2</sup>), the rice is used only for household consumption. Tradi-

tionally the fish are also only used only for domestic consumption.

New technology has been introduced, starting 3-4 years ago, with the assistance of Wu Yiming from the Zhejiang Freshwater Aquaculture Institute who is working with farmers and local officials to increase fish yields and therefore benefits to farmers while simultaneously trying to maintain a balanced ecological system. Breeding sites have been set up to produce fry for 1,500 mu (100 ha) of more intensive rice/fish culture. Baseline traditional yields of 40-80 kg/mu (600-1,200 kg/ha) have been increased to 300 kg/mu (4,500 kg/ha) with better shaped but still tasty fish. Fry were initially nursed

for 20 days to produce 1 g fingerlings with a higher survival rate but this has now been extended to 30 days to produce 5 g fingerlings. These are stocked in rice fields in June and fed formulated feed of different qualities for different stages and reach 250 g (up to 0.5-1 kg) in February. The best market size is 350-400 g.

One crop of rice is grown in the intensified system rather than two crops in the traditional system, which places less stress on the fish which grow year round. Cultivating two rice crops requires a lot of labour which is increasingly in short supply as younger family members emigrate or leave the farm for better paid employment in factories and the city. The rice yield remains the same at 450 kg/mu (6,750 kg/ha) but the grain is of better quality with only one crop of rice. There is no government pressure for farmers in the County to farm two rice crops.

Producing higher fish yields requires a higher level of technology and investment. Concrete walls are being built around some rice fields to maintain deeper water to raise more fish. However, short stemmed rice varieties cannot be grown as a tall variety is required in the 30-40 cm deep water for fish grow-out. When the rice is transplanted at the start of the season and fry are stocked, the water is only 10 cm deep. The temperature of the shallow water is suitable for the fry as temperatures are lower in early summer and water flows through the fields. Furthermore, rice seedlings



*Rice-fish farmers.*

are nursed for more intensive fish culture so that they are not too short when transplanted.

Farmers were initially reluctant to intensify their rice/fish system. They were advised to stock 500 fish/mu ( $0.75/\text{m}^2$ ) but would not as they said there was insufficient natural food in the rice field. On observing that artificially fed fish grow well, they began to intensify as they wanted to earn more. Unfortunately some farmers stocked  $> 1,000$  fish/mu ( $>1.5/\text{m}^2$ ) after 2-3 years as they said they wanted to harvest more fish which led to disease (red spot) due to poor water quality. One farmer interviewed obtained 350 kg fish from a 1 mu rice field with a trench, equivalent to a probably unsustainable yield of 5,250 kg/ha. He also obtained a reduced though still very high price of Yuan 24/kg (\$3/kg) when he sold the fish to restaurants as the fish raised at high stocking density with artificial feed is of lower quality.

During discussions with local officials, it was reiterated that the main aim of government intervention is to protect the rice/fish culture system heritage. The traditional system has been sustainable for 1,000 years but there are major concerns about continued sustainability with recent developments. In recognition of the traditional Chinese rice/fish system, it has been listed by FAO, UNDP and the GEF (Global Environment Facility) as a Globally-important Indigenous Agriculture Heritage System (GIAHS) in 2005. Demonstration sites are being set up in a wide range of agro-ecologies to adapt local practice so that farmers may live with the new opportunities and challenges brought about by globalization. The purpose of the GIAHS program is to develop appropriate policy, institutional support and technology to protect and promote important agricultural heritage such as the traditional Chinese mountain rice/fish system in Zhejiang Province.

I structured our final round table discussion around five aspects of sustainability: social, economic, technical, environmental and institutional. A unique social feature of the rice/fish system is the production of a high-value fish species. Farmers can make a good profit from raising the species but the quality of the fish and market price decline with intensification. An



*Holding pond for fish harvested from ricefields.*



*A restaurant dish prepared from ricefield carp.*

important research issue is the balance between quality and intensification to provide maximum profitability. As the carp is farmed in a clean environment without chemicals (neither inorganic fertilizers nor pesticides are used), the issue of branding as an organic food was raised.

A major concern is the declining farm population i.e., who will raise the fish in future? Up to 50% of the population of the densely populated mountainous county has emigrated but most young people are still leaving the farm or have every intention of doing so once they leave school. It is unlikely, as well as undesirable, that the global trend of declining farm populations will

not continue to take place in Qingtian County. This, however, should lead to fewer larger farms providing a more economically sustainable livelihood for the smaller number of people who wish to farm. While the intensified technology has led to increased production and profitability for a few trial farmers to date, the appearance of fish disease indicates a stressed system. Furthermore, intensification of fish culture usually leads to increasing eutrophication of the surrounding environment, especially in an intermittent or continuously flowing water system such as mountain rice terraces. Additional environmental problems raised were the need for increased amounts of water with inten-

sification which the area may not be able to provide; and pond construction by some farmers which would increase problems of water supply and eutrophication if it were to become widespread. Fortunately, there is not a problem with deforestation adversely affecting the rice/fish system as the government is protecting the mountain watersheds.

A supportive institutional framework is being developed for the County with local, national and international players taking part. However, considerable research is required to further the sustainability of the system. This should include surveys of current farmer practice, attitudes and aspirations and subsequently, participatory development with farmers of both technology and institutional support.

Unfortunately, I was unable to attend the workshop to agree on activities and a framework for decision making held at the end of July with local, national and international stakeholders due to a prior commitment. The workshop, “Globally Important Agricultural Heritage Systems (GIAHS) Traditional Rice-Fish Agriculture Multi-stakeholders Process Workshop” was organized by FAO and the Bureau of International Affairs, the Chinese Ministry of Agriculture, and co-organisers were Zhejiang Agriculture Bureau, Qingtian County, United Nations University, Wageningen University (The Netherlands), and the Institute of Geology and Resources of the Chinese Academy of Science. There were 80 officers, scholars, local leaders and farmers who



Monument celebrating the traditional rice-fish system.



Placard on the monument.



Gift to the author of a stone carving of rice and fish from Ye Minger.

attended. Participants visited rice/fish farms and about 20 speakers presented their opinions about how to protect the GIAHS and what the following action should be. Unfortunately for most of us, all the materials are in Chinese.

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# Reducing feed costs in aquaculture: Is the use of mixed feeding schedules the answer for semi-intensive practices?

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It is not an overstatement to say that the main research and development emphasis on Asian aquaculture, over the last decade or more, has been on shrimp culture, in particular on disease management and development of best culture practices. This emphasis or rather the over emphasis is understandable when one considers the revenue generated from shrimp culture, particularly in the form of foreign currency earnings to governments. In the above scenario, and in general, issues on fish nutrition have been somewhat pushed backstage, or at least have not received the attention that they should have been given amongst developers, planners and donor agencies. It is opportune to bring these issues to the limelight, for a number of reasons. Firstly, the fact remains that finfish aquaculture, and in particular inland finfish aquaculture, has been and will be the backbone of the industry for many more years and decades to come. Inland finfish culture also has two other important elements associated with it: Firstly that it is mostly rural and more often than not the practices are semi-intensive to extensive, thus its role as a key element in food security and poverty alleviation amongst rural masses in most countries. Secondly, it is often purported that in intensive and semi-intensive fish culture the main recurring cost is feed costs and it is therefore important to explore ways and means of reducing this cost element to ensure economic sustainability of the great bulk of semi-intensive aquaculture practices in Asia. An additional consideration is the global environmental concerns with regard to the use of fishmeal (Tacon, 2004), which is an ideal protein source but also the most expensive ingredient in feeds.



An equally important and an emerging issue in Asian aquaculture, particularly with the current relatively rapid growth of finfish mariculture is the heavy dependence on trash fish (De Silva & Phillips, 2006). The amount of trash fish utilized, mostly by this sector, is estimated to be around 1-2 million tonnes per year in Vietnam alone (Edwards et al. 2004). The pros and cons of using trash fish and related issues will be discussed in a follow up article.

## Reducing feed costs through changed formulation

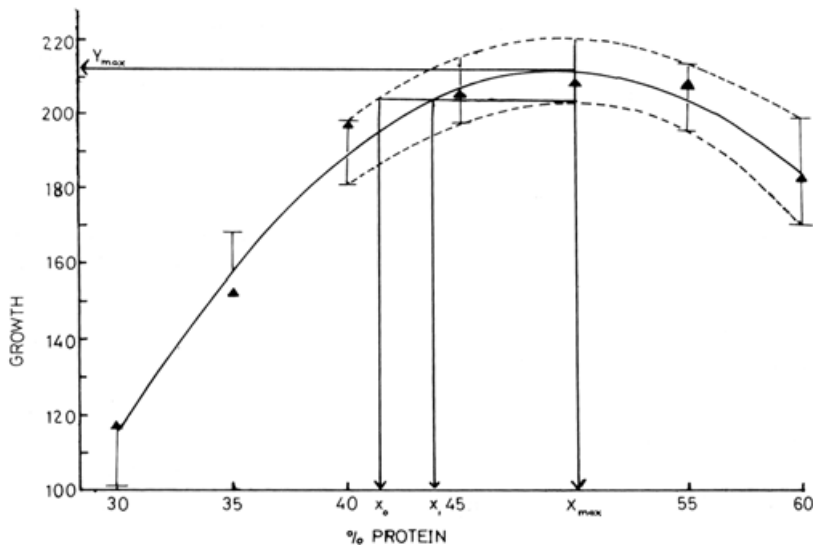
Reducing feed costs in aquaculture is therefore important for the longer term sustainability of the industry, and more so in respect of rural aquaculture where the profit margins often tend to be rather marginal. There is a potential for reducing feed costs in aquaculture by reducing unit feed cost per se and also through the adoption of prudent feed management strategies. In regard to the former the most obvious approach to

reduce the cost of feed is to decrease the amount of the most expensive ingredient in the feed, fishmeal, through substitution with a suitable, low cost alternative, while ensuring that such substitution will not compromise the growth and quality of the cultured stock.

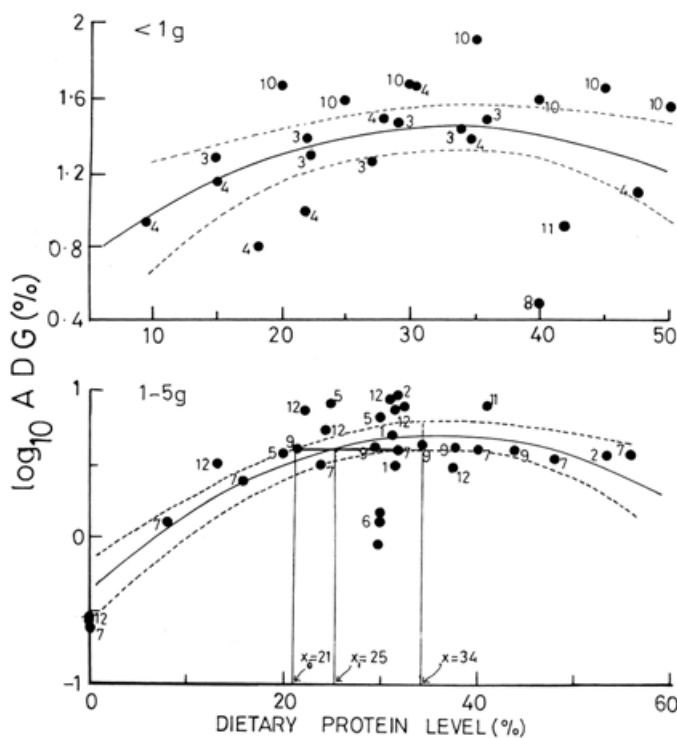
Is the above possible and if so to what degree has it being put in to practice? Indeed, it is possible; and if one were to scan the scientific literature, the greatest quantum of effort amongst nutritional researchers, all over the world, has been expended on research on fishmeal substitution in feeds. Although, complete substitution of fishmeal in feeds have been demonstrated only in a couple of cases, almost every ingredient tested, ranging from oil seed meals, pulses, leaf meals and various other agricultural by-products (for example, Tacon, 1987; Hertrampf and Pascual, 2000), as well as from recent times aquatic food product wastes (e.g. Rathbone and Babitt, 2000; Gunasekera et al., 2002) tested in laboratory experiments have shown to be capable



**Figure 1.** The second order polynomial relation (solid curve) of percent weight gain and dietary protein level, with 95% confidence limits (dotted curves).  $X_0$  and  $X_1$  are the approximate protein levels which minimize cost while maintaining an adequate growth.  $X_{max}$  is the level supporting highest growth (after Zeitoun et al., 1976).



**Figure 2.** Relationships of % ADG of tilapias, of <1g and 1-5g body weight, to dietary protein content. Nos. 1-12 refer to the sources of information: 1, Appler (1985); 2, Appler and Jauncey (1983); 3, Davis and Stickney (1978); 4, De Silva and Perera (1985); 5, De Silva and Gunasekera (1989); 6, Jackson et al. (1982); 7, Jauncey (1982); 8, Martinez-Palacios et al. (1988); 9, Mazid et al. (1979); 10, Santiago et al. (1982); 11, Tacon et al. (1983); 12, Wang et al. (1985).  $X$ ,  $X_0$  and  $X_1$  refer to the same parameters as in figure 1.



of replacing fishmeal to up to varying degrees, but mostly to about 40%, without compromising performance and or flesh quality.

The problem however, is that these research findings are rarely translated into practice, and in essence the main plant product ingredient used in commercially manufactured fish feeds still is restricted to soybean meal. It is appropriate to ask the question why this is so? Perhaps a number of factors are responsible for this; the relatively irregular supplies of some of these ingredients, and variation in quality in space and time thereof, possibility that some ingredients could affect the feed plant machinery, ingredient may affect pellet stability, undisclosed commercial reasons amongst others. The balance of evidence therefore, suggests that fishmeal substitution with low cost agricultural and/or other food industry products (waste) is not a strategy that is easily and or readily adopted by feed millers.

High energy diets utilize the protein sparing capabilities of a species, when the main energy requirements are met with from lipid and/or carbohydrate in the diet, which results in an overall reduction in feed costs. One of the best examples in this regard are salmonid diets which have over the years have resulted in a significant lowering in the protein component and a corresponding increase in the dietary lipid level to almost 30% or more, and a significantly better food conversion ratio (FCR). These developments have witnessed a steady decline in the FCR in salmonid culture (table 1) over the years and have become the industry standard. Of course it has also to be noted that apart from the quality of the feed per se other factors such as improved management, better feed handling and management would have contributed to this increase in feed utilization, but the exact contribution of these to improved FCRs are difficult, if not impossible to determine. However, not all cultured species have protein sparing capabilities that could be translated in to feed cost savings through changes to dietary composition, and particularly so for the bulk of the cultured, important, tropical fin fish species, perhaps with the exception of seabass (*Lates calcarifer*), which can be grown on high energy diets

Feed costs in all forms of aquaculture remain the highest recurring cost. Apart from the cost factor other issues related to use of fish meal and trash fish (particularly in Asian finfish mariculture) in aquaculture impacts on overall sustainability of the sector. Fish meal (and oil) replacement studies have generally been the main emphasis for reducing feed costs in aquaculture. This article attempts to show that in semi-intensive, small scale aquaculture practices feed costs can be significantly reduced by adoption of varying feed management practices, and may be more suited currently for small scale practices in the tropics.

(Boonyaratapalin and Williams, 2001; Glencross, 2006).

One element that has, however, received limited attention with the use of high energy diets is the reduction in phosphorus and nitrogen discharge in the form of metabolic waste as well as feed waste in to the environment.

### Formulated feeds - are we feeding diets that are too good for tropical semi-intensive practices?

As a general rule of the thumb, the cost of feed is directly proportional to the proportion of protein it contains - a consequence of the use of fishmeal as the major protein source. It is not surprising to find that in a great majority of practices feeds that are higher in protein content than required for growth are used. This is illustrated in respect of tilapia culture, which is becoming increasingly important in Asian aquaculture with a current production of 1.444 million tonnes. The protein requirement of *Oreochromis niloticus*, at different stages of growth, is well documented (table 2), and it has also been shown by De Silva et al. (1989) that the economically optimal dietary protein requirement for tilapia (as well as for major carps; De Silva & Gunasekera, 1991) in the young stages is about 25-28%. Figures 1 and 2, however, illustrate the

contention that the feeds used in tilapia culture (similar data available for major carps) may contain more protein than the dietary requirement, thus resulting in higher feed costs. The situation is further exacerbated in tropical semi-culture pond systems in which a species such as the tilapias are bound get some amount of nutrition from the system(s). "Over nutrition" does not result in any benefit, and apart from higher costs incurred it will also increase the nutrient loading in the systems and in effluent, with a potential of exacerbating eutrophication problems, and consequent public concerns on the industry.

### Feeding strategies: Mixed feeding schedules

The concept of "mixed feeding schedules" was developed by De Silva (1985), primarily based on the observations on the daily variation in apparent dry matter and protein digestibility of feed in the Asian chromid *Eetroplus suratensis* (Bloch) - one of the two cichlid species indigenous to Asia - and *Oreochromis niloticus* (L.) (De Silva & Perera 1983, 1984). The above observations led De Silva (1985) to hypothesize that when the fish are provided a high protein diet throughout the rearing period it might not be able to utilise the feed effectively to the same degree, day after day. This hypothesis was tested on young *O. niloticus* through the use of mixed feeding schedules where a high-protein diet (a diet containing the optimal protein requirement) was alternated with a low-protein diet (a diet containing approximately 10% less than the optimal requirement), each of these diets being fed alternately over a pre-determined number of days. The experimental results supported the findings that when fish maintained on certain mixed feeding schedules performed better or equally well as those fish maintained regularly on a high protein diet.

This initial concept has been furthered to include mixed feeding schedules that would entail using the same diet and alternating the quantity given to the fish (Patel and Yakupitiyage, 2003), alternate days of starving and feeding and so forth (Bolivar et al., 2006). In essence, a mixed feeding strategy is a strategy in which one

deviates from feeding the same feed, approximately in same amount, through the growth cycle. It is important to differentiate the difference between mixed feeding schedules and compensatory growth where the fish are starved for a substantial period and then fed (Ali et al., 2003).

What is important to point out is that use of mixed feeding schedules using two diets differing in protein content have been proven to be useful for many other cultured species such as the cyprinids common carp *Cyprinus carpio* (Sreekanth et al., 1989), catla, *Catla catla*, rohu, *Labeo rohita* and



Figure 3a & b (above and below). Farm-made feeds; the type of utensil/machinery, ingredients used and the final product are very variable.



common carp, (Nandeesh et al., 1993, 1994, 1995, 2002), Nile tilapia (Santiago and Laron, 2002; Patel and Yakupitiyage, 2003), *Channa striata* (Hashim et al., 1994), and on tilapia on-farm trials (Bolivar et al., 2006). Similarly, mixed feeding strategies that included the same feed but were managed on the principle of changed schedules of feeding gave comparable results (table 2, for details). In all of the above cases the latter did not result in a significantly lower growth rate or in differences in flesh quality. However, they did result in better FCR and significant savings on feed costs.

Mixed feeding schedule strategies not only result in feed cost savings, but equally importantly reduce nitrogen and phosphorous inputs in to the systems, and hence in the effluent, which is increasingly becoming a bone of contention for the industry. Mixed feeding schedule strategies, however, are another classic example where the research has not been translated into practice as much as it should have. It is a strategy that does not necessarily involve a “third party” such as a feed manufacturer, and its adoption is entirely in the hands of the practitioner, which should make it so much easier to be translated into practice.

### Farm made feeds

In the Asian context aspects on feeds and feeding cannot ignore the vast dependence of aquaculture practices that depend on “farm made” feeds.

The great bulk of farm made feeds are supplementary feeds used in semi-intensive practices (New et al., 1993), but could also be complete feeds for some of the intensive culture practices of carnivorous species such as the snakehead, *Ophicephalus* spp., the fast growing Pangasiid culture in the Mekong Delta, South Vietnam (Le Thanh Hung, pers. Comm.; Phillips and De Silva, 2006). The degree of sophistication of farm made feeds therefore, is very varied (figure 2), and is related to the intensity, species cultured, size of the operation, ease of accessing suitable raw materials, etc. Needless to say the current practices are open to much improvement that could result in better feed utilization and hence feed cost savings. For example, in peri-urban culture practices farm made feeds may use food processing industry waste, kitchen waste and the like. There has been very limited if any technical input into improving the quality of farm made feeds, a strategy that has been strongly advocated (De Silva and Davy, 1992). Such improvements would not only reduce feed cost but also would positively impact the performance of the stock, improve shelf-life of feeds, and save time in preparation. A case in point with regard to the efficacy of “farm made feeds” was aptly demonstrated in a study on shrimp, in Andhra Pradesh, India, which also happened to defy all conventional nutritional wisdom (Wood et al., 1992); a stark proof that much more could be achieved with regard to

**Table 1: Changes in the calculated average FCR in salmon farming (A.G.J. Tacon, pers. Comm.).**

Period	FCR
1983-1985	> 2.0
1986-1990	1.7
1991-1995	1.6
1996-2000	1.5
2001-2003	1.4
Current 2004	1.3

“farm made” feeds through relevant research and development programs.

One of the emerging trends with regard to farm made feeds is the establishment of rural, small scale feed millers, particularly in India. Surprisingly or not, in India, which is the second leading nation in aquaculture production in the world (accounted for 2.466 million tonnes in 2004 of which nearly 93% was freshwater finfish; FAO, 2006), very limited commercial feeds are used in finfish pond culture. There is a growing trend for farmers to indicate to these small scale feed millers the ingredient composition of the feed they require, and the feed millers prepare the required feed in small quantities. This process does not require the farmer to purchase the ingredients and or store, and enables him/her to get a diet according to the specifications. This strategy also opens a window, particularly to rather entrepreneurial farmers, to experiment with diets, perhaps leading to better feed utilization and cost-effectiveness (De Silva, 2006). It will be interesting to observe how this new trend progresses into the foreseeable future.

### Conclusions

In general, over the years, and especially since the aquaculture sector was alerted to the potential problem on fish meal availability, as a possible limiting factor in its growth surge (Wijkstrom and New, 1989), the emphasis has been to concentrate on finding suitable alternatives for fish meal. Needless to say these efforts have had much impact on the sector, but primarily on industrial scale fish culture, and particularly on relatively high valued, mostly cold water cultured species such as the salmonids. What can not be ignored is that in



Farm-made feed drying in the sun.

**Table 2. Previous studies on mixed feeding schedules in fish (HP - high protein; LP - Low protein; the numbers in column six refers to the number of days each diet each diet was presented.**

Species	Rearing conditions	Feeding habit	Weight (g)	Feed used (% protein)	Best schedule(s)	Author
<i>Catla catla</i>	Outdoor cement tanks	Omnivore	0.5	15.9 (LP), 31.8 (HP)	1LP/3HP	Nandeesh et al. (1993)
<i>C. catla</i>	Earthen ponds	Omnivore	2.2	9.5 (LP), 42.6 (HP)	1HP/1LP	Nandeesh et al. (1994)
<i>Channa striata</i>	Indoor fibreglass tanks	Carnivore	0.6-1.0	33.5 (A), 35.1 (B), 46.7 (C)	1A/2C	Hashim (1994)
<i>Cyprinus carpio</i>	Outdoor cement tank	Omnivore	1.9	16.4 (LP), 31.0 (HP)	1LP/3HP	Srikanth et al. (1989)
<i>C. carpio</i>	Earthen ponds	Omnivore	1.1-5.1	9.5 (LP), 42.6 (HP)	1HP/1LP	Nandeesh et al. (1994)
<i>C. carpio</i>	Outdoor cement tank	Omnivore	0.53	16.0 (A), 26.2 (B), 31.7 (C)	2A/2C	Nandeesh et al. (1995)
<i>C. carpio</i>	Outdoor cement tanks	Omnivore	0.3	16.7 (A), 19.7 (B), 25.6 (C), 30.9 (D)	2A/2D	Nandeesh et al. (2002)
<i>Labeo rohita</i>	Outdoor cement tank	Omnivore	0.8	15.9 (LP), 31.8 (HP)	1HP/1LP	Nandeesh et al. (1993)
<i>L. rohita</i>	Indoor plastic tanks	Omnivore	3.1-4.1	18.4 (LP), 38.9 (HP)	2LP/3HP	Mohanty & Samal (1994)
<i>L. rohita</i>	Earthen pond	Omnivore	2.7-20.6	9.5 (LP), 42.6 (HP)	1HP/1LP	Nandeesh et al. (1994)
<i>M. peelii peelii</i>	Indoor glassfibre tanks	Carnivore	22.8	40.6 (LP), 50.0 (HP)	1HP/1LP	Unpublished (Wu et al.)
<i>O. niloticus</i>	Indoor glassfibre tanks	Omnivore	0.2-1.1	18.2 (LP), 30.4 (HP)	2LP/3HP	De Silva (1985)
<i>O. niloticus</i>	Indoor glassfibre tank	Omnivore	1.9	18.0 (LP), 25.0 (HP)	1LP/2HP & 1LP/ 3HP	Santiago & Laron (2002)
<i>O. niloticus</i>	Hapas in earthen ponds	Omnivore	13.6±2.6	(a) 22 (LP), 33 (HP) (b) HFR (2.3%), LFR (1.5%)**	(a) 2A/3B (b) 2HFR/ 3LFR	Patel & Yakupitiyage (2003)
<i>O. niloticus</i>	On-farm	Omnivore	0.19	Alternate day feeding (AD)*	AD	Bolivar et al. (2006)

Feeds of differing protein content used at each grow out stage for 157 days.  
\*\*\* High and low feeding rates % body weight per day using the 33 % protein diet.

Asia, the cradle of aquaculture development, by and large the practices remain relatively small scale, rural, often clustered together, and semi-intensive. This scenario is likely to be retained to the foreseeable future. Consequently, the impacts of fish meal replacement in feeds, for fin fish, in most of Asia may be of limited immediate significance in

achieving sustainability and reductions in feed costs.

It is in the above context that other relevant strategies of feed cost reduction, with a accompanied reduction on environmental discharge of nutrients, have to be considered as a matter of urgency. The available evidence suggests that there are simple, easily adoptable

strategies available for reducing feed costs, particularly so in semi-intensive aquaculture, as practiced in Asia; practices that contribute the great bulk to global aquaculture production. The profit margins in small scale aquaculture, as seen in Asia, are rather narrow; any cost saving measure increases the economic viability of such operations.

Importantly, the measures suggested are also environmentally sounder, contributing to “more environmentally friendly” aquaculture practices. There is an urgent need to bring this information to “model and or demonstration” farms in a given area and or adopt an “on farm” extension/dissemination strategy.

References

Ali, M., Nicieza, A., Wootton, R.J., 2003. Compensatory growth in fishes: a response to growth depression. *Fish and Fisheries*, 4: 147-190.

Bolivar, R.B., Jimenez, E.B.T., Brown, C.L., 2006. Alternate-day feeding strategy for Nile tilapia grow-out in the Philippines: marginal cost-revenue analysis. *North American Journal of Aquaculture*, 68: 192-197.

Boonyaratapalin, M., Williams, K.C., 2001. Asian sea bass, *Lates calcarifer*. In: *Nutrient requirements and Feeding of Finfish in Aquaculture* (CD Webster, CE Lim, eds.), pp.40-50. CABI Publishing, UK.

De Silva, S.S., 1985. Performance of *Oreochromis niloticus* (L.) fry maintained on mixed feeding schedules of differing protein content. *Aquaculture and Fisheries Management*, 16: 331-340.

De Silva, S.S., 2006. Feeds in Asian aquaculture: the key to its long term sustainability. *FAO Fisheries Technical Paper* (in press).

De Silva, S.S., Davy, F.B., 1992. Strategies for finfish nutrition research for semi-intensive aquaculture in Asia. *Asian Fisheries Science*, 5: 129-144.

De Silva, S.S., Perera, M.K., 1983. Digestibility of an aquatic macrophyte by the cichlid *Etroplus suratensis* (Bloch) with observations on the relative merits of three indigenous components as markers and daily changes in protein digestibility. *Journal of Fish Biology* 23, 675-684.

De Silva, S.S., Perera, M.K., 1984. Digestibility in *Sarotherodon niloticus* fry: effect of dietary protein level and salinity with further observations on variability in daily digestibility. *Aquaculture* 38, 293-306.

De Silva, S.S., Phillips, M.J, 2006. Cage farming in Asia. *FAO Fisheries Technical Paper* (in press).

De Silva, S.S., Gunasekera, R.M., Atapattu, D., 1989. The dietary protein requirements of young of tilapia and an evaluation of the least cost dietary protein levels. *Aquaculture*, 80: 271-284.

De Silva, S.S., Gunasekera, R.M., 1991. An evaluation of the growth of Indian and Chinese major carps in relation to the dietary protein content. *Aquaculture*, 92: 237-241.

Edwards, P., Tuan, L.H., Allan, G., 2004. A survey of marine trash fish and fish meal as aquaculture feed ingredients in Vietnam. *ACIAR Working paper* 57, 56 pp. ACIAR, Canberra, Australia.

FAO, 2006. *Fishstat.Plus*.

Glencross, B., 2006. The nutritional management of barramundi, *Lates calcarifer* - a review. *Aquaculture Nutrition*, 12: 291-309.

Gunasekera, R. M., Turoczy, N. J., De Silva, S.S., Gavine, F., Gooley, G.J., 2002. An evaluation of the potential suitability of selected aquatic food processing industry waste products in feeds for three fish species, based on similarity of chemical constituents. *Journal of Aquatic Food Product Technology*, 11, 57-78.

Hashim R., 1994. The effect of mixed feeding schedules of varying dietary protein content on the growth performance of *Channa striata* fry. *Asian Fisheries Science* 7, 149-155.

Hertrampf, J.W., Pascual, F.P., 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer Academic Publishers, London, 573 pp.

Nandeesh M.C., De Silva S.S. & Krishna Murthy D. (1993) Evaluation of mixed feeding schedule in two Indian major carps, catla (*Catla catla*) and rohu (*Labeo rohita*). In: *Fish Nutrition in Practice*, 4th International Symposium of Fish Nutrition and Feeding, Biarritz, France, June 1991 (ed. by S.J. Kaushik & P. Luquet), pp. 753-765. INRA, Paris, France.

Nandeesh M.C., De Silva S.S., Krishna Murthy D., 1995. Use of mixed feeding schedules in fish culture: Performance of common carp, *Cyprinus carpio* L., on plant and animal protein based diets. *Aquaculture Research* 26,161-166.

Nandeesh M.C., De Silva S.S., Krishna Murthy D., Dathathri K., 1994. Use of mixed feeding schedules in fish culture: field trials on catla, *Catla catla* (Hamilton-Buchanan), rohu, *Labeo rohita* (Hamilton), and common carp, *Cyprinus carpio* L. *Aquaculture and Fisheries Management* 25, 659-670.

Nandeesh M.C., Gangadhara B., Manissery J.K., 2002. Further studies on the use of mixed feeding schedules with plant-and animal-based diets for common carp, *Cyprinus carpio* (Linnaeus). *Aquaculture Research* 33, 1157-1162.

New, M.B., Tacon, A.G.J., Csavas, I. (eds.), 1993. *Farm-Made Aquafeeds*, FAO/ RAPA/AADCP, Bangkok, Thailand.

Patel, A.B., Yakupitiyage, A., 2003. Mixed feeding schedules in semi-intensive pond culture of Nile tilapia, *Oreochromis niloticus*, L.: is it necessary to have two diets of differing protein content. *Aquaculture Research*, 34: 1343-1352.

Phillips, M.J.P., De Silva, S.S., 2006. Finfish cage culture in Asia: an overview on status, lessons learned and future developments. *FAO Fisheries Technical Paper*.

Rathbone, C.K., Babitt, J.K., 2000. Whitefish offals make great fish feeds. *World Aquaculture*, 31: 20-24.

Santiago C.B. & Laron M.A. (2002) Growth and fry production of Nile tilapia, *Oreochromis niloticus* (L.), on different feeding schedules. *Aquaculture Research*, 33, 129-136.

Srikanth G.K., Nandeesh M.C., Kesavanath P., Varghese T.J., Shetty H.P.C, Basavaraja N., 1989. On the applicability of a mixed feeding schedule for common carp, *Cyprinus carpio* var. *Communis*. In: *Aquacultural Research in Asia: Management Techniques and Nutrition* (Proceedings of the Asian Seminar on Aquaculture, Malang, Indonesia, 14-18 November 1988) (ed. by E.A. Huisman, N. Zonneveld & A.H.M. Bouwmans), pp. 254-260. Pudoc. Wageningen, the Netherlands.

Tacon, A.D.J., 1987. The nutrition and feeding of farmed fish and shrimp - a training manual. 2. Nutrient sources and composition. *GCP/RLA/075/ITA*, Field Document 5/E. FAO, Rome, Italy, 129 pp.

Tacon, A. G.J., 2004. Use of fish meal and fish oil in aquaculture: a global perspective. *Aquatic Resources, Culture and Development*, 1, 3-14.

Wood, J.F., Brown, J.H., MacLean, M.H., Rajendran, I., 1992. Feeds for artisanal shrimp culture in India - their development and evaluation. *BOBP/REP/52*, Bay of Bengal Programme, Madras, India. 60 pp.

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



# Seed production technology of ornamental gouramis *Colisa fasciata* and *C. lalia* under captive conditions – an experience in Assam, India

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Gouramis are medium sized fish belonging to the family Osphronemidae. The banded gourami *Colisa fasciata* and the dwarf gourami *C. lalia* are fascinating to observe and popular in the aquarium trade because of their brilliant colours, with alternating bands of orange and red on their flank. The dorsal and anal fins extend right up to the tail. The red-orange spots on these fins and the long barbel-like ventral fin add to the distinctive beauty of these fish. Both species are capable of breathing air through the accessory 'labyrinth organ' that is characteristic of gouramis and related species, and make occasional movements to the surface to gulp air.

## Habitat

We have collected large number of these fishes locally from wetlands infested with macrophyte weeds, but they are also found naturally in shallow ponds. In nature we have recorded a minimum size of 3.6 cm and a maximum size of 5.1 cm for adult *C. lalia*, and a minimum size of 5.0 cm and maximum of 8.3 cm for *C. fasciata*.

## Captive breeding of the banded gourami, *Colisa fasciata*

### Sexual dimorphism

Males banded gouramis are generally larger than females of the same age and much brighter in colour. In males, the obliquely disposed lateral bands on the body are peacock blue. In the female these bands are a dull steel-gray. In males, the ventral fin is a single ray which becomes orange-red later, whereas in case of females it is yellowish-gray. During breeding season the dorsal and anal fins of the male become peacock blue with an orange border, while those of the female become yellowish-grey.

The female shows an enlarged abdomen while the male has slender belly during breeding season. On the other hand the genital papilla of the females is in the form of a prominent bulge, which can be mechanically raised through pressure on its sides. The male has no such structure, and males do not ooze milt.

### Feeding behaviour

Banded gouramis are omnivorous, feeding on algae, zooplankton and soft aquatic vegetation along with small insect larvae such as mosquitoes, mayfly and tubifex worm.

### Breeding

#### Breeding season

Banded gouramis prefer to breed in the monsoon period. Breeding activity starts from April and lasts up to the month of August. In captivity we observed this species to mature at around 10-12 months old, at a size of around 6.5 cm for males and 5.2 cm for females.

#### Breeding habit

Banded gouramis have the habit of building 'bubble nests' in which they lay and incubate their eggs. Males prepare the nest by gulping air from the surface which they use to blow fine bubbles mixed with saliva to create a

floating foamy structure, usually building around a piece of plant or debris on the surface. Small leaves, stems and pieces of root may also be used as construction materials, carried by the male in his mouth.

The male first attracts a mature female to the nest; if she is not ready to spawn, the male may become aggressive and cause serious injury. The female releases eggs near the nest at intervals, which the male fertilizes and then carries to the nest in his mouth, blowing them into the bubble nest. The entire spawning process lasts for about 2-3 hours. The male guards continuously until the larvae hatch and become free swimming.

### Broodstock management

Banded gouramis do not require any sophisticated arrangement, breeding freely when a congenial environment is created in a glass aquarium. The administration of inducing hormone is not necessary and indeed may lead to high mortality in these relatively small fish, therefore we recommend using environmental manipulation to stimulate spawning.

Prior to conducting breeding trials we stocked six males together with four females in a 1m<sup>3</sup> cement cistern with 40cm water depth. Water parameters recorded on the day of release were as follows: pH:7.5, water temperature 23.5°C, air temperature 28.5°C. The tank included some aquatic plants including water hyacinth and *Salvinia natan*. The broodstock were fed daily twice ad libitum with daphnia powder, tubifex and prepared diet. Before conducting captive breeding trials, male and female gouramis were separated and reared in two different aquariums for 10-15 days. Due to the nature of spawning behaviour in this fish the optimum breeding ratio is 1 female : 1 male.

### Suggested tank setup and water parameters for breeding

Over the course of our experiments we have found that water quality parameters conducive to spawning in banded gourami are in the range of: pH 7-8, temperature 25-27°C., dissolved oxy-

gen 4-6 mg/l; phosphate 1.0-1.5 mg/l and total hardness 0.2-0.5 mm/l.

We favour the use of small aquaria of around 80cm x 40cm x 40cm for captive breeding banded gourami, using a mixture of rain water and ground water in a 1:1 ratio. For easy maintenance the water depth in the spawning tank can be maintained around 8-10cm during spawning, and lowered to around 5cm when the larvae become free swimming. Small floating plants with fine leaves or roots are a preferred spawning substrate and suitable species include *Salvinia* sp., *Ceratophyllum* sp., and *Ludwigia* sp.; however small sized *Eichhornia crassipes* may also be used.

### Eggs and larval growth

The eggs are round and typically 0.7-0.8 mm in diameter, being translucent in colour, floating and non-adhesive. Fecundity is typically in the range of 4,100-4,700 eggs per gram of ovary. Fertilized eggs hatch in 24-30 hrs at a temperature of around 27-28°C. After hatching the larvae complete yolk absorption after around 60-70 hours.

We observed differential growth of larvae under captive conditions. The total length of new hatchlings is generally about 2.0 mm. They may reach around 1.0 cm in length in three weeks and 5.7 cm in twelve months under aquarium conditions. Juvenile fish first begin to develop colour at around 14 weeks old.

### Larval rearing and feeding

Maintaining a shallow water depth in the larval rearing tank is important to help facilitate atmospheric respiration, so we typically maintain the water level at around 5cm. The aquarium should be provided with good amount of aquatic weeds with fine leaves to give the young fish shelter.

We followed the following feeding regime: For the first five days infusoria-rich water three times per day; from day 6-15 infusoria and boiled egg yolk emulsion alternately, four times per day; from day 15 onwards fish may be fed boiled egg yolk emulsion, daphnia powder, mosquito larvae and other prepared foods.

This approach gave us good results with a typical fertilization rate of 95%,

hatching rate of 88% and mean survival of larvae around 79% after 30 days.

## Captive breeding of the dwarf gourami, *Colisa lalia*

As its name suggests the dwarf gourami is quite a small species; however it is very colourful with a brilliant rainbow hue on its flanks. The natural habitat of this fish is shallow wetlands and it is also found in adjacent paddy fields. It grows up to around 5 cm in length and 2.5 g in weight.

### Sexual dimorphism

The dwarf gourami has distinct sexual dimorphism. Male fishes are slightly longer and brighter in colour than the females. Females are dull grey in colour and possess a bulging abdomen when mature. Males become more attractive during the breeding season. The breeding and feeding habit and suitable water parameters for breeding this fish are similar to those described above for the banded gourami.

### Breeding

The optimum breeding ratio is 1 male : 1 female. It is best to select females that are at least 4-4.5 cm in length as better results will be obtained from larger spawners. Following our breeding trials, we found that the average fecundity of females was around 615-803 eggs/g body weight, with individual females producing an average of 1,108 eggs (equivalent to 5,540 eggs/g ovary). Eggs were translucent and free floating, and around 0.6-0.7 mm in diameter. We recorded average fertilization rates of 90% and hatching rates of 92%.

Eggs hatched after approximately 24 hours incubation in the bubble nest at a temperature of 28°C. Hatchlings are around 1.7-2.0 mm in length, and may reach 1.0 cm after one month and 4.0 cm after 12 months under aquarium conditions.

### Larval rearing and feeding

We obtained good results using the same larval feeding regime described for banded gourami above. Around

*Continued on page 32.*

Asia-Pacific Marine Finfish Aquaculture Network



# Magazine



## Second Workshop on Economics and Marketing of Live Reef Fish in the Asia-Pacific - held at the WorldFish Center, Penang, Malaysia

Brian Johnston, Australian National University

The Australian Centre for International Agricultural Research (ACIAR) is funding a three-year research project to study the economics and marketing of live reef food fish (LRFF) fisheries and trade. It aims to identify the necessary conditions for the sustainability of supply and trade in the long term (Johnston and Yeeting, 2006).

The first workshop for the project was held in Noumea, New Caledonia, 2-5 March 2005. This brought key researchers from around the Asia-Pacific together for the first time in order to present the project to the Pacific Island countries involved in the trade. The workshop was successful in gaining their participation, including the sharing of information among fishery managers and discussion of the potential usefulness of the modeling approaches being developed for the project. The first workshop also secured the ongoing participation of Indonesian fishery researchers.

The second workshop, hosted by the World Fish Centre (WFC) in Penang in March 2006, provided the opportunity researchers to present the major findings of their research for peer group review and to identify critical gaps in the research to date. The proceedings of both meetings have been published by ACIAR (Johnston and Yeeting 2006) and are available for download from:

and are available for download from: <http://www.aciar.gov.au/web.nsf/doc/ACIA-6MP3SJ>.

### Demand for live reef food fish

Live reef fish are a high income food product. As incomes rise in Asia, particularly China, the demand for LRFF is expected to grow strongly. Three papers examine aspects of demand for live reef fish for food consumption. Dr Madan Dey's paper provides an overview of the importance of fish in the food consumption of Asian economies and how the WFC has undertaken analysis of the future demand for fish using estimated price and income elasticities derived from country data. The income elasticities for all fish types was found to be positive, implying that as incomes rise in Asia, the demand for fish for food will continue to rise. This has major implications for the ability of fishery systems to continue to meet this demand.

Dr Liz Petersen's paper includes an analysis of the demand for LRFF in the major market, Hong Kong. It found that price is not an important determinate of wholesale demand in the Hong Kong market, but income is. Live reef fish can be considered a luxury item of food consumption and is relatively unresponsive to price compared to other fish products.

Ms Noel Chan's paper utilises a taste test procedure to identify whether consumers could discriminate between

wild caught and cultured fish samples of the same species. A triangle taste test method was used and a sample of consumers was presented with three fish samples, one of which was different. The samples were presented "blind" to the consumers and they were asked to identify the odd sample and provide a judgement whether the odd sample was wild-caught or cultured. It was found that just over 50% of the consumers were able to correctly identify the odd sample. 37% of the consumers correctly identified the odd sample as either wild-caught or cultured. There was a general preference for the wild-caught sample, although the cultured fish sample was quite acceptable to all consumers sampled.

### Developments in aquaculture

Because the future supply of wild-caught LRFF is highly constrained due to the effects of overfishing and destructive fishing practices (Sadovy et al 2003), future growth in supply to meet rising demand is likely to come mainly from aquaculture. Recent developments in aquaculture production in the Asia-Pacific region are described in a paper by Dr Mike Rimmer and colleagues. This paper is an update



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on their paper presented in the first workshop proceedings (Johnston and Yeeting, op.cit.). The aquaculture production of LRFF species (principally grouper species) is expanding rapidly in Asia as demand for these fish species exceeds supply from wild-caught sources. China's role in aquaculture production and consumption of LRFF species is significant yet remains poorly understood. Given the likely continued growth in incomes in China and its aquaculture capacity in other species, there is a need to gather better market intelligence on LRFF developments in China.

The Network of Aquaculture Centres in Asia-Pacific (NACA), based in Bangkok, Thailand is playing a major co-ordinating role in the development of cultured seafood industries in the region. Mr Koji Yamamoto outlines this role and covers NACA's work in improving market access and trade, food safety and trade issues, regional co-operation and information dissemination. A number of the challenges facing aquaculture are being tackled through the Asia Pacific Marine Finfish Aquaculture Network (APMFAN) and these have direct relevance to the production and trade in live reef fish species.

**Analysis of the market chain**

Fishers in relatively poor countries supplying the LRFF trade are often not in possession of good market information. This arises because the market chain from catching to consumption is long and often involves the fish changing ownership along the chain. A frequent complaint from fishers in remote Pacific countries particularly, is that more transparency is required in the market chain. Geoffrey Muldoon and Bill Johnston in their analysis examine the impact of mortality and price risk on the costs and value distribution along the LRFF chain. They describe the market chain and develop a conceptual model which includes capital and distribution costs at each point in the chain and the possible impact of risk on production and mortality of the fish as they are transported to the market in Hong Kong. A spreadsheet model which incorporates these aspects is developed, with the intention of applying it to case

studies in Indonesia and Papua New Guinea in the next stage of the work.

The production and marketing of the LRFF trade in Indonesia is examined in detail in Dr Sonny Koeshendrajana's paper. The paper reviews relevant background literature on the LRFF in Indonesia and provides valuable information on the production structures and financial returns from both wild-caught and aquaculture LRFF. Following the collection of data from key Indonesian institutions associated with the LRFF, field visits and surveys were used to verify the information. In the wild-caught sector the main types of fishing are trap and hook and line, although evidence is also found for illegal fishing using cyanide. Aquaculture production has expanded rapidly since 1999 and now forms an important source of production. The author favours the establishment of a government plan of action to encourage sustainable live-reef fisheries in Indonesia and the removal of destructive practices from the fisheries.

**Integrating supply and demand analysis**

In order to integrate developments in Asia fisheries and to make future projections, the WorldFish Centre has developed a supply and demand model. The development of the base model and its structure is outlined by Dr Madan Dey. The model, which includes the nine key supplying and consuming countries in Asia, includes demand functions for all main food fish species and supply functions for both wild-caught and aquaculture fisheries. In its base structure, LRFF are excluded, but this is taken up a following paper by Dr Roehl Briones. Baseline projections and projections of the Asia Fish Model under different future scenarios are presented. Key future scenarios examined are higher productivity in the production of low and high value fish in aquaculture, reducing fishing effort and compliance with HACCP/SPS requirements.

In order to develop forward projections of trends and developments in the LRFF trade, the WorldFish Centre was commissioned to extend its AsiaFish model to include supply and demand relationships for live reef fish. Dr

Roehlano Briones outlines in his paper how this was done and presents some preliminary projections from the initial modeling effort. The AsiaFish model had to be extended in two main ways to incorporate LRFF trade. First, data was collated on LRFF in the main producing and consuming countries to allow the AsiaFish model modified to incorporate this. Second, data on individual countries' supply and demand had to be incorporated into the model and the major demand centres of Hong Kong and China included. The basic data and modeling approach is outlined, production and consumption and supply and demand elasticities are provided in the paper, along with data weaknesses. Three exporting countries are included in the initial model – Indonesia, Malaysia and the Philippines with the remaining exporters aggregated into 'Other'. Some simple projections are undertaken to explore the possible effects of management and technology on the fisheries and trade effects. It was found that the model was sensitive to elasticity estimates for HK/China as well as elasticities of substitution.

Dr Akhmad Fauzi in his paper outlines a new approach to modeling live reef fisheries in Indonesia. In his research he applies the theory of the backward bending supply curve in a fishery to examine the dynamic conditions in a live reef fishery where the resource is limited and overexploitation can easily occur. Applying this approach to a case study based on the Indonesian LRFF in Southern Sulawesi yields some interesting results. Most notable is that if the fishers continue to respond to increasing demand by additional fishing effort, without regard to the impact on the productivity of the fishery, a chaotic dynamic occurs and the fishery collapses. This implies that fishers need to be fully informed about the possible consequences of increasing effort as prices rise and the need to ensure that there is in place controls over access to the resource. Further research is needed to validate the parameters of the model and to examine the economic, environmental and social consequences of new management approaches in the LRFF in Indonesia.

## Regulation and management of the trade

In the paper by Mr Being Yeeting of the Secretariat of the Pacific Community (SPC), the situation regarding LRFF in the Pacific is examined. The paper examines the background and history of the trade, the efforts made to address issues of overfishing and resource exploitation, the current problems and initiatives underway to address them. Two key areas for future work are identified: better understanding of the resources to ensure their effective management and the development of effective management and local capacity. It is concluded that the effective management of the LRFF trade to ensure the long term sustainability of the fisheries in the Pacific requires the application of the precautionary principle to fisheries resource access and to apply ecosystem based management to the fisheries. SPC will continue to provide support to the nations of the Pacific to ensure this objective is achieved.

The policy options for the regulation and management of the LRFF are reviewed by Geoffrey Muldoon in the final paper of the workshop. It is concluded that the unique features of the live reef fisheries across the Asia-Pacific region will make effective management difficult to implement. These features include the limited productivity of the fisheries, the widespread areas from which fish are taken which makes policing of illegal fishing practices difficult and the limited resource information currently available on which to base effective management strategies. Further work is needed to identify the costs and benefits of possible management strategies that could be implemented to change these fisheries from open-access to managed fisheries. Such analyses need to consider economic, environmental and social aspects.

## Conclusions

The workshop participants agreed that the final stages of the project needed to focus on developing projections on further development of the LRFF trade, taking into account likely constraints on growth in the wild-caught sector which in many cases was already fully or over-exploited. In contrast, scope for

expansion exists in the aquaculture sector of the LRFF trade, particularly as the technology of hatchery production of higher value species becomes more widely adopted. The aquaculture sector dependent on juvenile fingerlings or young fish caught from the wild is also likely to be highly constrained due to reduced stocks of wild fish.

The model developed by the World-Fish Center has considerable potential to provide projections of supply and demand of LRFF from the major Asian countries already participating in the trade or developing major aquaculture capacity, such as China. It was agreed the model be extended to include all major Asian producers (Indonesia, Malaysia, Philippines, Thailand), China and 'Other' (which includes Australia and Pacific Island countries). There is a need to include both the wild capture and aquaculture sectors in each country and two categories of production, low priced species and high priced species. Demand would be modeled for Hong Kong and China.

The market chain model also has considerable scope for further development, to include case studies of Asian and Pacific Island country fisheries and to include risk analyses. The information collected on the Indonesian fishery would provide a strong basis for a case-study, for example.

A key challenge for the future is to identify management arrangements that would effectively constrain fishing effort in many wild-caught fisheries and stamp out unsustainable practices that damage coral reefs, such as cyanide and use of explosives. The team will focus on these issues in the next stage of the project, to identify potential benefits and costs of improved management arrangements for the wild-caught fisheries across Asia and the Pacific.

The potential for aquaculture to meet the rising demand for live reef fish as incomes grow across Asia and China is promising, but there are many issues warranting ongoing research. This economics and marketing project is closely integrated with the ACIAR marine finfish aquaculture project being co-ordinated by Dr Rimmer. Key issues for further research and development are focused on improving the long-term sustainability of aquaculture to support the LRFF trade as well as other

markets. These include improving the quantity and quality of seedstock supply from hatcheries, developing sustainable grow-out feeds, documenting and promoting best management practices and addressing market issues. The growing affluence of China is a key demand issue to be studied, as is the current stated consumer preferences for wild-caught over aquaculture product. Consumers also seem to have a growing awareness of the negative impacts of both capture fisheries and aquaculture, and demand is increasing for sustainably-produced products. Improving the sustainability of the LRFF trade through both capture fisheries and

aquaculture remains a significant challenge for fishers, traders, merchants and governments.

### Next steps

A number of follow-up actions were initiated from the workshop. The WorldFish Center is being contracted to extend the Live Reef Fish model to include China and Thailand as supplying countries, to include two broad categories of LRFF – higher and lower value species and to allow welfare effects to be captured in the model output. The market chain model is to be further developed to include risk analy-

sis and to develop two possible case studies – one for a Pacific country and one for Indonesia. The demand analysis is to continue, to incorporate later data where this is available. All authors are continuing to develop their papers in preparation for publication in the final report for the project, due in 2007. Overall, the workshop was very successful in providing high quality input into the research project, identifying gaps in data, information and analysis and in providing expert guidance for the next stage of the work.



## Marine finfish market information and aquaculture development trends in selected locations in Indonesia and Malaysia

Sih Yang Sim, NACA

### Kukup, Johor (Malaysia)

Kukup is the third largest marine finfish cage culture area in Malaysia. Most farms are owner/investor operations with support from family members, and farm workers are commonly overseas labourers. Most farms have operated for more than 10 years and farming of species such as groupers, snappers, cobia, trevallies, pompano, threadfins and seabass.

There are about 60 farms in Kukup area with an average of about 150 cages per farm, or around a total of 9,000 cages in this location alone. The daily trade volume in Kukup is around 7-10 tonnes of marine finfish, either for local markets or for export to markets including Singapore, Hong Kong and elsewhere in Malaysia. The marine finfish farm gate prices at Kukup are listed in Table 1, the prices are for reference only and were obtained in the first half

of December 2006. It is important to note that different markets require different sized table fish, particularly in the restaurant sector. Malaysian restaurants in Johor prefer fish that is around 0.9-1.1 kg, while Singapore restaurants prefer fish at 15 inches which is by their definition equal to one kg.

Increasingly many farmers moving toward farming of new marine finfish species which are produced in hatcheries and adapted to take commercial

pelleted feed, for example, pompano, cobia, threadfin, and snappers. However, commercial feeds are still expensive at about RM 3.50/kg, and FCR is relatively high at around 3 to 4. Whether the high FCR is due to high mortality rate of stock (60-75%) or/and poor feed management is yet to be determined.

### Lampung, Belitung Island, Situbondo, Bali and Batam (Indonesia)

Most marine finfish farms in focus on high value species such as groupers. The development trend for grouper farming in Indonesia has been driven by the availability of hatchery produced grouper fingerlings, mainly *Cromileptes altivelis* (humpback grouper)

and *Epinephelus fuscoguttatus* (tiger grouper). Recently, *Plectropomus leopardus* (coral trout) and *E. caeruleopunctatus* (white-spotted grouper) are being produced in hatcheries in Indonesia and grow-out of these two species is being trialed by farmers in Indonesia.

The fingerlings prices for various marine finfish species in Indonesia are listed in Table 2, these prices are for reference only and were collected during 13 November-18 December 2006. It is interesting to note that even for same species such as humpback and tiger grouper fingerlings, at different locations the price varied around 20-30%, with farmers in Lampung paying highest prices for grouper fingerlings.

Many farmers growing marine finfish species produced in hatcheries

are moving towards use of commercial feed at nursery stage where they find that it provides good growth rates and fingerlings/juveniles are healthier. However, at grow-out stage farmers still feel that fresh feed such as trash fish provides better growth rates and therefore prefer to use trash fish over commercial feed. Commercial feed currently priced at around Rp 12,000 to 15,000/kg with FCR ranging from 1.5 to 2.5.

There is increasing utilization of pen systems for farming grouper. Pens used in Indonesia do not have a fixed size. Some farmers use 10 x 15 m, 12 x 12 m and some are much larger at 40 x 60 m. Based on the feedback received from farmers using pen systems, it appears

**Table 1: Marine finfish farm gate price at Kukup in Malaysian Ringgit (RM).**

No	English Name	Scientific Name	Size	Price/Kg	Comments
1.	Green groupers	<i>Epinephelus coioides</i> <i>E. malabaricus</i> ; etc	0.8-1 kg	RM 30-32 S\$ 15.5	Malaysia/Hong Kong/Singapore
2.	Tiger grouper	<i>E. fuscoguttatus</i>	0.8-1 kg	RM 35	Sold to Hong Kong boat
3.	Seabass	<i>Lates calcarifer</i>	0.5-1 kg	RM 14	
4.	Fourfingers threadfin	<i>Eleutheronema tetradactylum</i>	0.5-1 kg	RM 20 (cage) RM 16 (pond)	Fish from cages fetch higher price than ponds
5.	Pompano	<i>Trachinotus blochii</i>	0.5-1 kg	RM 16-18	Direct to restaurants
6.	Red snapper	<i>Lutjanus malabaricus</i>	0.5-1 kg	RM 18	n/a
7.	Mangrove snapper	<i>L. argentimaculatus</i>	0.5-1 kg	RM 18 RM 15	Fish for fishing fetch higher than table fish
8.	Golden trevally	<i>Gnathanodon speciosus</i>	0.5-1 kg	RM 18	n/a
9.	Giant grouper	<i>E. lanceolatus</i>	n/a	RM 40-50	n/a

**Table 2: Marine finfish fingerlings prices in various location in Indonesia.**

No	English Name	Scientific Name	Size	Price/cm	Location
1.	Green groupers	<i>Epinephelus coioides</i> <i>E. malabaricus</i> etc	6 inches	Rp 10,000/fish (wild) Rp 600	Batam Batam
2.	White-spotted grouper	<i>E. coeruleopunctatus</i>	2.7-3 cm	Rp 1,200-2,000/fish Rp 1,500	Bali Bali
3.	Tiger grouper	<i>E. fuscoguttatus</i>	100-200 gram	Rp 1,000-1,100 Rp 400-500 Rp 500-800 Rp 500-600 Rp 18,000/fish	Lampung Situbondo Bali Batam Batam
4.	Humpback grouper	<i>Cromileptes altivelis</i>	4-6 cm	Rp 1,250-1,500 Rp 1,000 Rp 1,000 Rp 45,000/fish	Lampung Situbondo Bali Batam
5.	Coral trout	<i>Plectropomus leopardus</i>	100 gram	Rp 1,500 Rp 20,000/fish	Bali Batam
6.	Seabass	<i>Lates calcarifer</i>	7 cm	Rp 2,000/fish	Batam
7.	Mangrove snapper	<i>L. argentimaculatus</i>	3 cm	Rp 2,300/fish Rp 400-500	Batam Batam
8.	Golden trevally	<i>Gnathanodon speciosus</i>		Rp 400	Batam

Note: US\$1 = RM3.50; US\$1 = S\$ 1.52.



Orange spotted grouper (green grouper) *Epinephelus coioides*.



Wildcaught juvenile duskytail grouper (green grouper) *Epinephelus bleekeri*.



Mangrove snapper, *Lutjanus argentimaculatus*.



White-spotted grouper, *Epinephelus caeruleopunctatus*.



Hatchery produced coral trout fingerlings, *Plectropomus leopardus*.



Fingerlings of white-spotted grouper.

that the survival rate and feeding efficiency also improved.

Alternative farm made feed has been developed for marine finfish by farmers in Batam where they use dry anchovy head as fishmeal source and mixed with flour at a 7:3 ratio. The FCR is about 4 in comparison to total trash fish which is around 6 to 12, depending on the quality of the trash fish used.

The farm gate prices for various marine finfish species in Indonesia are listed in Table 3, these prices are

for reference only and were collected during 13 November-18 December 2006. There are many different farm gate prices for each location. Some farmers have indicated that as they are selling smaller quantities than some larger players so the prices they receive are lower. The variation can also be the result in the fluctuation in currency conversion between US dollar and Indonesian rupiah, the exchange rates used can vary from US\$1 = Rupiah 8,500 to Rupiah 9,100. Most of the

farmed marine finfish are for export markets, including Hong Kong and Singapore.



Pen culture system for marine finfish, Indonesia.

**Table 3: Marine finfish market prices at various location in Indonesia.**

No	English Name	Scientific Name	Price/Kg	Location
1.	Green groupers	<i>Epinephelus coioides</i>	Rp 50,000	Lampung
		<i>E. areolatus</i>	Rp 35,000 (dead)	Lampung
		<i>E. malabaricus</i>	US\$ 5	Lampung
		<i>E. caeruleopunctatus</i>	Rp 80,000-95,000	Batam
		<i>E. bleekeri</i>	Rp 220,000	Batam restaurant price
		<i>etc</i>	Rp 350,000	Bali restaurant price
2.	Tiger grouper	<i>E. fuscoguttatus</i>	Rp 72,000-75,000	Lampung
			US\$ 7.5-9.5	Lampung
			Rp 50,000-70,000	Bali
			Rp 250,000	Bali restaurant price
			Rp 60,000-80,000	Batam
			Rp 200,000	Batam restaurant price
3.	Humpback grouper	<i>Cromileptes altivelis</i>	Rp 300,000	Lampung
			Rp 317,000	Lampung
			US\$ 40-47	Lampung
			Rp 250,000-300,000	Bali
			Rp 750,000	Bali restaurant price
			Rp 400,000	Batam
4.	Coral trout	<i>Plectropomus leopardus</i>	Rp 110,000	Lampung
			Rp 200,000	Bali
			Rp 150,000-170,000	Batam
5.	Coral trout species	<i>Plectropomus spp.</i>	US\$ 27	Lampung
			Rp 500,000	Bali restaurant price
6.	Seabass	<i>Lates calcarifer</i>	Rp 25,000 (dead)	Lampung
			Rp 40,000-45,000	Batam
			US\$ 8.5	Batam
7.	Golden trevally	<i>Gnathanodon speciosus</i>	Rp 60,000	Batam
8.	Napoleon wrasse	<i>Cheilinus undulatus</i>	Rp 600,000	Batam
			Rp 750,000	Bali restaurant price
9.	Mangrove snapper	<i>L. argentimaculatus</i>	Rp 50,000-65,000	Batam
10.	White spotted rabbitfish	<i>Siganus canaliculatus</i>	S \$50-60 (Chinese New Year)	Batam
11.	Giant grouper	<i>E. lanceolatus</i>	S\$ 16	Batam

Note: US\$1 = RM3.50; US\$1 = S\$ 1.52.



*Above: Farmer building fish pen system. Below: Individual pen culture system.*



## Brief overview of the 2<sup>nd</sup> International Symposium on Cage Aquaculture in Asia (CAA2)

The 2<sup>nd</sup> International Symposium on Cage Aquaculture in Asia (CAA2), jointly sponsored by the Asian Fisheries Society (AFS), Zhejiang University (ZJU) and the China Fisheries Society, was successfully completed from 3<sup>rd</sup> to 8<sup>th</sup> July 2006. The symposium, held in the new ZJU campus in the city of Hangzhou, was attended by some 300 participants from over 25 countries.

### Sessions of CAA2

The CAA2 provided a very comprehensive program covering all the major issues pertinent to the development of cage culture in the world. There were eight concurrent sessions during the three days allocated to the symposium. The sessions included:

- Freshwater cage culture.
- Marine cage culture.
- Nutrition, feed and feeding.
- Environmental impacts and management.
- Disease prevention and health management.
- Policy, management, economics and markets.
- Open forum.
- Industries session.

In addition to the technical sessions, there were two Special Lectures, five Keynote Speakers and the FAO's global review on cage aquaculture development with presentations from nine speakers.

For serious technicians and researchers on cage aquaculture, the nine FAO global review papers will be of great interests as they outline the latest technology development and techniques on cage culture in countries in the European Union, South America and Asia.

Proceedings of CAA2 will be published in the first half of 2007 and the FAO global cage culture reviews will be attached as a CD to the CAA2 proceedings.

AFS Secretariat will make an announcement on its website [www.asianfisheriessociety.org](http://www.asianfisheriessociety.org) when the CAA2 proceedings is published and details



for obtaining a copy of the proceedings will be made available on the web. Copies of the CAA2 proceedings can also be purchased during the 8<sup>th</sup> Asian Fisheries Forum to be held in Cochin, India from 20<sup>th</sup> – 23<sup>rd</sup> November 2007.

### ACRSP Awards

The Aquaculture Collaborative Research Support Program (ACRSP) based in the Oregon State University, USA sponsored the Best Environment Papers and Best Student Papers during the CAA2.

The three best papers on environment and aquaculture were:

1. Yufeng Yang and Xiugeng Fei on the "Development of mariculture and bioremediation of seaweeds in Chinese coastal waters".
2. R. Mayerle, W. Windupranata and K.J. Hesse on "Decision support system for sustainable environmental management of marine fish farms".
3. Chongkim Wong, Chingyee Tse and Kingming Chan on "DNA damage as biomarker for assessing effects of suspended solids on cage-cultured marine fish".

The best student paper prizes were won by:

1. Huiwen Cai and Yinglan Sun on "Environmental carrying capacity of cage aquaculture based on dry matter conversion rate in Xiangshan Harbor".
2. Shannan Xu, Hanye Zhang, Shanshan Wen, Kun Luo and Peimin He on "Integrating seaweeds into

marine fish cage culture systems: a key towards sustainability".

3. Yusheng Jiang and Xinzhong Wu on "Characterization of a Rel/NF- $\kappa$ B homologue in a gastropod abalone, *Haliotis diversicolor supertexta*".

### Acknowledgements

Many organizations, institutions and individuals have supported and contributed to the success of CAA2 and to them, we would like to express our sincere appreciation. However, the following are specially acknowledged for their contribution to CAA2:

- Professor Wu Xinzhong, Mr Chen-Jian, Dr Xu Haisheng and staff of the Secretariat and the Organizing Committee of CAA2.
- The seven Special Lecturers and Keynote Speakers – Dr Meryl Williams, Prof Xu Junzhou, Prof Yngvar Olsen, Dr Zilong Tan, Dr Arne Fredheim, Dr Ulf Erikson and Prof Ho Ju-Shey.
- The FAO Global Cage Aquaculture Review managed by Dr Matthias Halwart and presented by nine senior authors of the reviews – Dr Albert Tacon, Prof Sena De Silva, Mr Jiaxin Chen, Dr Alejandro Rojas, Dr Chris Bridger, Dr Jon Grotum, Dr Matthias Halwart, Dr Shivaun Leonard and Dr Francesco Cardia.
- Chairs of the Scientific Committee and Editorial Board - Prof Zhou Yingqi, Dr Yangyi and Prof Sena De Silva.

Last but not least, the Secretariat sincerely thanks to all the trade exhibitors, participants and AFS Councillors.



# Skretting Scholars take new knowledge home after NACA Hatchery Course

Graham Look



*Skretting Scholar James David, the general manager of a shrimp hatchery in India.*

Scholars funded by Skretting to attend the NACA Grouper Hatchery Course report they are taking new knowledge to support the development of hatcheries in their home countries.

The Fourth Regional Grouper Hatchery Production Training Course was organised by the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Brackishwater Aquaculture Development Centre at Situbondo in Indonesia. Twenty participants represented 13 countries, from Qatar to Australia, on an intensive course that ran from 20 November to 9 December 2006.

Skretting offered three scholarships to provide financial support, including travel and accommodation, for people actively working in private aquaculture production. The 2006 Skretting Scholars were Pramote Sangsukirikul, a lecturer in sea bass breeding and farm management and a hatchery owner from Thailand; Hla Pe, a senior technician and hatchery operations manager in Myanmar; and James David, the general manager of a shrimp hatchery in India.

Pramote Sangsukirikul describes the course, which combines hands on learning with lectures from industry

and academic experts. "Participants are divided into four groups and each group is given a larvae tank to manage, under the supervision of the trainers and technicians. The training activities included larvae tank preparation, egg collection, larviculture, feed and grading. I benefited greatly and will share the knowledge with fellow hatchery operators and government officers in Thailand. Already, I ran a small workshop at the end of December. Hopefully, through cooperation we can start to produce grouper fingerlings in our hatcheries.

"The training course also provided us with opportunities to build friendships with participants from other countries. Many participants became good friends during the training course and will keep in touch. Everyone will use the knowledge from this training course to improve marine finfish culture in his or her home country so, hopefully, marine finfish culture in Asia Pacific can develop and progress further."

James David comments, "My ambition was to gather knowledge in marine fish hatchery technology, to adapt the technology to native marine species in India and facilitate diversification

of species away from the tiger shrimp. The most important practical training related to spawning and larval rearing. Luckily for us, both species humpback (*Cromileptes altivelis*) and the tiger grouper (*Epinephelus fuscoguttatus*) started spawning and we were able to spawn, collect eggs, hatch and rear both species.

"Every section head showed the utmost care and patience in answering questions — no matter how simple. We picked up tips and precautions in algal and rotifer culture, feed preparation and PCR (polymerase chain reaction) protocols that were valuable even for experienced participants.

"Field trips to hatcheries, fish farms and cage culture farms were an important supporting component. The hatcheries we visited gave us insights into the commercial and economic aspects of grouper hatchery and farming. All the private hatcheries owners and technical staff freely shared their experiences. At the end of the course we visited the Gondol Research Institute of Mariculture in Bali.

"For participants with hatchery experience this course emphasizes the areas where we have to concentrate our



*Skretting scholar Pramote Sangsuksirikul, a lecturer in sea bass breeding and farm management and a hatchery owner from Thailand.*

attention. It helped clear our doubts and crystallize our thinking. For example, most of us had assumed that super small rotifers were essential for larval rearing of carnivorous fish such as grouper. However, the BADC uses only small rotifers. We actually measured the size of the rotifers to confirm the size. This gave us confidence that we could manage in our own countries with native rotifer strains and have successful larval runs.

“I am grateful to Skretting for opening the doorway to a new future. Now back in India, I am submitting a Concept Note for a project on a marine food fish hatchery to the newly established National Fisheries Development Board in the Indian Ministry of Agriculture. I am also preparing a presentation on grouper hatcheries for the College of Fisheries, Mangalore, and for my colleagues in the shrimp industry.”

“The sponsorship of Skretting Scholars helps to tackle the bottleneck in aquaculture caused by low productivity in hatcheries in the Asia-Pacific



*Skretting Scholar Hla Pe, a senior technician and hatchery operations manager from Myanmar.*

region,” says Rik van Westendorp, Managing Director of Skretting Japan.

“For many small private aquaculture enterprises in Asia, such a course can be extremely useful but much too expensive when travel and accommodation are taken into account. As Skretting is expanding its activities in the

Asia Pacific region and is introducing hatchery feeds, we feel that sponsorship of Skretting Scholars on this NACA hatchery management course is entirely appropriate.”

A detailed report on the outcomes of the training course will be in the next issue of *Aquaculture Asia*.

# Market analysis of the live reef food fish trade

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The live reef food fish trade is a high value-to-volume fishery, with Hong Kong imports estimated at 15-20,000 tonnes and valued at approximately US\$350 million (Muldoon and McGilvray 2004). Sadovy and Vincent (2002) estimate that 60 percent of the international trade goes to Hong Kong, with as much as 50 percent of this being re-exported to southern mainland China. While fish consumption has been a staple dietary component of these countries for centuries, live reef fish are consumed in especially high quantities during special occasions and festivals (for example, in celebration of Chinese New Year, Mothers' Day and to mark the close of business agreements). Approximately twenty Asia-Pacific countries supply these markets, with Thailand, the Philippines, Australia, Malaysia and Indonesia being the dominant suppliers (ACFD 2003). The live reef fish trade is not a traditional market. Supply from south-east Asia and the Indo-west has only established in the 1990s, with Pacific island countries and fishers in some Asian countries fluctuating as suppliers. Demand centres are developing

in mainland China and the west coast of the USA, and trade constraints are changing rapidly (e.g., trade barriers in China).

A number of economic, environmental and social issues have arisen as a result of the trade. There are concerns about the sustainability of supply due to economic and biological over-exploitation of coral reefs and the environmentally damaging aspects of some harvesting techniques; including cyanide fishing and targeting of spawning aggregations (Cesar et al. 2000). Cyanide is still widely used, albeit illegally, throughout Southeast Asia and in some Indo-west Pacific countries (Johannes and Riepen 1995), and can be fatal to corals and non-target reef fish (Jones and Steven 1997). Over-fishing of live reef species is reported in many Asia-Pacific countries, leading to the dissipation of fishery rents and the erosion of future harvest potential. Several desirable live reef fish species form aggregations to spawn. Fishing of these aggregation sites improves catch rates but can remove much of the breeding stock, with consequent negative effects on reproductive populations. Many live reef fish are long-lived and slow to reach sexual maturation and thus prone to overfishing (Cesar et al. 2000). Increasingly, fish are being caught before reaching sexual maturation, and grown-out in cages until they are market size, again eroding the reproductive potential of the fish populations.

Potential benefits from substituting wild-caught fish with cultured species depend on how successfully the mariculture industry relieves its dependence on wild stocks for juveniles and trash fish (Sadovy and Lau 2002). Moreover, the market impacts, and specifically price impacts, of this substitution may have significant effects on fisher income.



Preliminary data analysis indicates that the live reef fish trade has been susceptible to economic shocks such as the Asian Economic Crisis and, to a lesser extent, Severe Acute Respiratory Syndrome (SARS). The impacts of these shocks are felt throughout the supply chain, from the fisher to the retailer, to different degrees. Moreover, the trade is beset by social disruption, which arises mainly due to disputes over resource access and use, distribution of benefits, and the use of destructive fishing practices. In many cases, while the trade has provided additional income generating opportunities, these benefits have come at a cost to future ecological, economic and social sustainability.

## The demand for live reef fish

During times of high seasonal demand, both wholesale and retail prices can be higher than usual for high-value fish and some medium-value species (Sadovy et al., 2004). Demand for live reef fish has also been affected by Severe Acute Respiratory Syndrome (SARS), which was first identified in the Chinese province of Guangdong in November 2002, and had reached Hong Kong by February 2003 (Pet-Soede et al., 2004). The outbreak caused a short-term decrease in demand for live reef food fish due to the resulting decline in outdoor dining, tourism and air travel



services (Pet-Soede et al., 2004). By the end of June 2003, the World Health Organisation cleared Hong Kong from infection. Although SARS created a temporary downturn in consumer prices, there was a greater impact on the exporting countries (Sadovy et al., 2003).

### **Demand analysis - results and discussion**

The demand analysis is based on the monthly price data from the International Marinelife Alliance who conducted surveys of wholesale and retail outlets over the time period from January 1999 to July 2003. Wholesale prices were monitored monthly at wholesalers/distributors in Quarry Bay and Wanchai, and twice weekly from markets in Kwun Tong and Aberdeen. Prices are expressed as real 1999 Hong Kong dollars. Quantity data was sourced from formal data collected by the Hong Kong Census and Statistics Department (CSD) and data provided voluntarily by traders to the Hong Kong Agriculture, Fisheries and Conservation Department (AFCD).

The nine major live reef fish species are divided into two categories – high and low-valued species – according to Table 1. A demand system is estimated using these two species categories.

The own-price elasticities of both the high and low-value categories (bolded in Table 2) are inelastic. The high-value own-price elasticity is larger than the low-value own-price elasticity. This is in accordance with trends in fisheries literature where more valuable seafood generally exhibit more elastic demand (Asche and Bjorndal 1999). The cross-price elasticities are negative indicating they are complementary goods. For example, when the price of high-value species increases, the quantity demanded of low-value species also increases, and vice versa. While this is unexpected and may be due to data deficiencies, it may also indicate that a range of fish is consumed simultaneously. For example, quantities of high-value species may be complemented by the consumption of low-value species at the same meal, and vice versa.

The expenditure elasticities (Table 3) are positive indicating that they are normal goods – as expenditure on live

reef fish increases, the consumption of live reef fish also increases. The expenditure elasticity of low-value species is elastic, indicating that when expenditure on live reef fish increases, relatively more green grouper will be purchased. The income elasticity of high-value species is inelastic (although, only slightly lower than unity), indicating that when expenditure on live reef fish increases, relatively less leopard coral trout will be purchased.

A SARS dummy variable was introduced to analyse the impact of economic shocks on demand (Table 4). The results indicate that SARS caused expenditure shares to shift from high-value species to low-value species by approximately 7 percent. This may be the result of a decrease in patronage at restaurants where high-value live reef fish are largely purchased, and an increase in consumption of supermarket-purchased low-value live reef fish species.

### **Demand analysis - summarising comments**

These results have a number of supply implications. Demand for live reef fish is relatively unresponsive to price compared with other fish products (most fish products are price elastic (Asche and Bjorndal 1999)). Hence, quantity supplied may be determined more by supply-side factors (such as availability of stock, and transport and transaction costs) than demand-side factors (such as price).

Furthermore, consumers were found to substitute high-value species for low-value species during the SARS outbreak. Hence, while low-value species provide the lowest gross revenue per unit volume (net revenue minus supply and transaction costs) compared with high-value species, they may pose the lowest supply risk, at least when considering demand-related influences.

These results should be considered with caution given the deficiency of data. Unfortunately, price data is no longer being collected and hence, analysis for a longer time-period is not possible. Moreover, Chinese New Year was not found to have a significant impact on demand. This may be because income growth was low during the time period over which the data was

collected. Chinese New Year may be found to have a significant impact during periods of strong economic growth.

## **Market integration in the live reef food fish trade**

### **Market integration – background**

Supplies of live reef food fish (LRFF) to Hong Kong, with the exception of those in Australia, come predominantly from artisanal and subsistence fisheries. These fisheries are characterised by their low gear technology, geographic remoteness of fishing grounds, long distances between these grounds and export hubs and markets, large numbers of landing sites and under-developed storage and transport infrastructure. For these reasons the market chain for the live reef food fish trade is both extended and complex with product passing through many levels of trade between the fisher and the restaurant. Furthermore, high transport costs associated with maintaining and exporting a live product has led traders in supply countries to form vertical relationships with those in Hong Kong in order to export their product. This has tended to the belief that transmission of price information between agents at the supply end of the market chain is restricted and that market power is concentrated among Hong Kong traders, who garner most of the gains from trade.

In practice, gains may be unevenly distributed among agents for a variety of reasons including the disproportionate marketing costs and risks borne by agents at specific points along the market chain. This is particularly so in the live reef food fish trade where poor handling and husbandry techniques in supply countries have historically increased risk of mortality and poor fish health (e.g. ciguatera) (Sadovy and Vincent, 2002). Empirical study on marketing margins, market integration and price causality will partly inform this debate regarding market power in the live reef food fish trade. Marketing margins will be compared with other empirical studies. Market integration is required for market power to exist. Price causality tests show whether there is on central market that affect price setting in other markets (not necessarily



in an uncompetitive manner), including smaller regional markets.

**Data sources**

Hong Kong prices for live reef fish from November 1999 to July 2003 were obtained from surveys carried out by the International Marinelife Alliance (IMA). Average monthly retail prices were drawn from 726 restaurants in 18 districts around Hong Kong with 150 restaurants randomly selected each month. Wholesale prices were collected twice weekly from markets in Kwun Tong and Aberdeen and monthly from wholesalers/distributors in Quarry Bay and Wanchai and averaged over the month. Data on beach prices in supplying countries was sourced from formal data collected by the Hong Kong Census and Statistics Department (CSD) and data provided voluntarily by traders to the Hong Kong Agriculture, Fisheries and Conservation Department (AFCD).

All prices are real prices and are presented in constant November 1999 Hong Kong dollars.

**Examining spatial integration of aggregated wholesale and retail prices**

Aggregate wholesale and retail price trends for the nine key live reef fish species are shown in Figure 1 (in real November 1999 prices). The average wholesale price for the period is HK\$193/kg, the average retail price is HK\$336/kg, and the average marketing margin is HK\$143/kg or 74.0% of wholesale price. On average, wholesale prices vary more than retail prices; the coefficient of variation of wholesale price is 10.9% and that of retail price is 6.54%.

Dynamic regression analysis was conducted using retail and wholesale prices. Firstly, retail price was used as

the independent variable and a range of different lag structures for retail and wholesale prices were introduced.

Secondly, wholesale price was used as the independent variable and a range of different lag structures for retail and wholesale prices were introduced. Joint exogeneity tests that the retail price parameters are equal to zero could not be rejected for each of these lag specifications.

These results indicate that wholesale prices, both in the current period and with a geometric lag, are causing retail prices with no evidence of causality in the opposite direction. This suggests that wholesale and retail live reef fish prices form part of a system of live reef fish prices that may vary independently in the short-run, but in the long run, they will vary simultaneously as part of a single market where wholesale prices takes the role of the price leader.

**Examining spatial integration of aggregated wholesale and beach prices**

Aggregated beach and wholesale price trends are shown in Figure 2. The average beach price for the period is HK\$106/kg, the average wholesale price is HK\$193/kg, and the average marketing margin is HK\$87/kg or 82% of wholesale price. On average, wholesale prices tend to vary more than beach prices; the coefficient of variation of wholesale price is 10.9% and that of beach price is 7.17%.

These results indicate that wholesale prices, both in the current period and with a geometric lag, are causing beach prices with no evidence of causality in the opposite direction. This suggests that wholesale and beach live reef fish prices form part of a system of live reef fish prices that may vary independently in the short-run, but in the long run, the will vary simultaneously as part of a single market where wholesale prices takes the role of the price leader.

**Examining market integration of beach and wholesale prices by species and country of origin**

As shown in Table 1, the two most highly traded species are leopard coral trout and green grouper. This section is an examination of market integra-

tion between beach and wholesale prices of the major exporters of these two species. Leopard coral trout is a relatively high-value species that is largely sourced from wild-stocks (either as adults, or as juveniles and then cultured), whereas green grouper is a relatively low-value species that is largely cultured (approximately 60 percent are cultured from hatchery-bred juveniles and 40 percent from wild-caught juveniles) (Mike Rimmer, pers comm.).

Table 5 provides average beach price information for leopard coral trout and green grouper by major exporters. Australia, Philippines and Indonesia are the major exporters of leopard coral trout, and Thailand and the Philippines are the major exporters of green grouper. The average beach price received differs for each of these exporting countries. In the case of leopard coral trout, the coefficient of variation also differs across exporting country, where Australian fishers are exposed to the greatest variability in price compared with Indonesia and the Philippines. The marketing margins for leopard coral trout are 90 – 115% of beach price (the Philippines receive a lower beach price and hence marketing margins are significantly higher). These margins are significantly higher for leopard coral trout than green grouper which are 20-40% of beach price (in this case, Thailand receives a lower beach price and has a higher marketing margin).

**Market integration – summarising comments**

The results indicate that in aggregate, retail and wholesale prices in Hong Kong and beach prices from source country, are integrated. This suggests that market prices move synchronously in the long-term and vary simultaneously as part of a single market. When



**Table 1. Average monthly quantity traded and weighted average wholesale price of key live reef fish species imported into Hong Kong (January 1999 to December 2003).**

	Average monthly quantity traded (t)	Weighted average wholesale price (HK\$/kg)
<b>Aggregate of all species</b>	<b>351</b>	<b>177</b>
<b>High-value species</b>	<b>195</b>	<b>264</b>
• Highfin grouper	1	513
• Humphead wrasse	2	451
• Leopard coral trout	160	281
• Giant grouper	2	191
• Tiger grouper	8	184
• Spotted coral trout	7	177
• Flowery grouper	15	169
<b>Low-value species</b>	<b>156</b>	<b>85</b>
• Green grouper	126	92
• Mangrove snapper	30	53

**Table 2. Price elasticities for high and low-value species<sup>a</sup>.**

	Elasticity of demand for:	
	High-value species	Low-value species
<b>With respect to the price of:</b>		
High-value	<b>-0.81** (16.08)</b>	<b>-0.12** (2.91)</b>
Low-value	<b>-0.82** (3.76)</b>	<b>-0.48** (2.72)</b>

*a: Own-price (in bold) and cross-price elasticities are calculated using the uncompensated elasticity formula.*

*\*\* indicates significance at the 5 percent level.*

**Table 3. Live reef food fish expenditure elasticities for high and low-value species.**

High-value species	Low-value species
0.93** (25.48)	1.30** (8.26)

*\*\* indicates significance at the 5 percent level.*

**Table 4. Parameter estimates for the SARS dummy variable, by value category.**

High-value species	Low-value species
-0.072** (3.88)	0.072** (3.87)

*Note: Values in parentheses are t-statistics. \*\* indicates significance at the 5 percent level.*

**Table 5. Price and marketing for leopard coral trout and green grouper by major country of origin.**

	% of trade	Ave BP (HK\$/kg)	CVBP (%)	Margin (HK\$/kg)	Margin/BP (%)
Leopard coral trout					
• Australia	43	146	12	131	89.7
• Indonesia	15	147	7	130	88.4
• Philippines	29	129	5	148	115
Green grouper					
• Philippines	20	73	11	15	20.5
• Thailand	53	63	11	25	39.7

*\*\* More than 10% of the trade.*

analysing the two most traded species, leopard coral trout and green grouper, evidence of market integration was found between wholesale prices and beach prices for leopard coral trout sourced from Indonesia and the Philippines, but no market integration for leopard coral trout sourced from Australia, or green grouper in general. This latter finding may be due to data deficiencies, the export of significant quantities of green grouper and leopard coral trout from Australia to an external markets (for example, the west coast of the United States), or the presence of market power in the marketing chain.

There are sizeable differences between beach and wholesale prices (82% of beach price) and between wholesale and retail prices (74% of wholesale price). Compared with marketing margins for other seafood products, these marketing margins are relatively high. Within European seafood markets, margins between processors and retailers for salted cod in Norway are between 26% and 36% while margins between wholesalers and retailers of fresh salmon in France are around 38% for whole fresh fish

**Figure 1: Wholesale and retail prices aggregated across nine key restaurant species marketed within the live reef food fish trade in Hong Kong.**



and 58% for fresh salmon fillets. The marketing margin between leopard coral trout beach prices and wholesale prices in Hong Kong of approximately 100% is consistent with margins for imported products in European seafood markets (Asche et al. 2002, Gonzales et al. 2002, Fofana et al. 2003).

Wholesale prices were found to be weakly exogenous. It may be that retailers are allowing wholesalers to set their prices on the basis of the supply costs, including risk and uncertainty, they face. We suggest that the wholesaler in Hong Kong is the vertical price leader along the whole live reef food fish market chain. Their financial support to intermediaries in supply countries (Indonesia, the Philippines, Malaysia) allows them to set prices upstream, while the disproportionate costs and risks associated with that stage of the supply chain allows them to set prices for downstream agents as well.

### Discussion and conclusions

The results presented in this paper have highlighted a number of issues relating to the marketing of the live reef food fish trade. Firstly, demand is unresponsive to price relative to other fish products. Hence, supply-side factors (such as the availability of stock, and transport and transaction costs) rather than demand-side factors (such

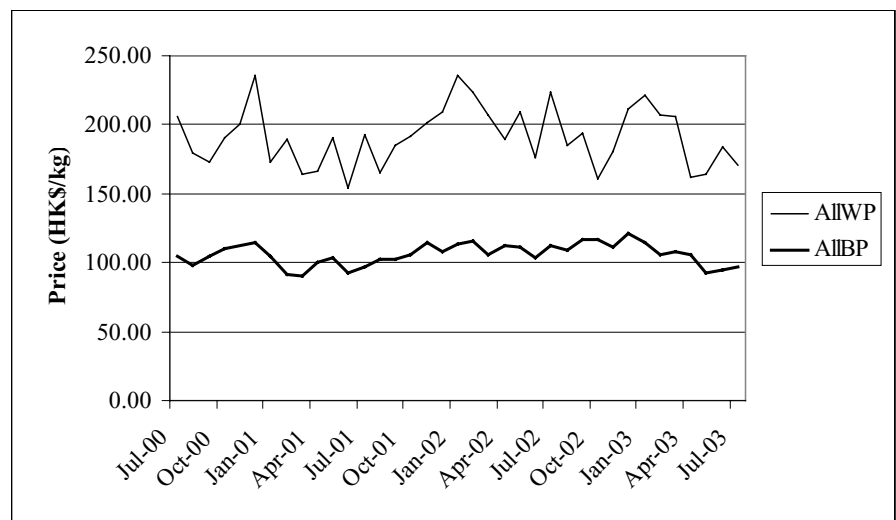
as price) are likely to have the greatest affect on quantity supplied. However, it should be noted that economic growth in Hong Kong and southern mainland China is likely to put upward pressure on supply in the medium term.

Secondly, demand for live reef fish is susceptible to economic shocks, as was evidenced in the recent SARS epidemic. During these shocks, consumers substitute from relatively high-value restaurant-consumed live reef fish, to relatively low-value supermarket-purchased live reef fish. Thirdly, there is evidence of market integration between live reef fish sourced from a number of Asian

countries, and wholesale and retail markets in Hong Kong. Generally, wholesalers were found to exhibit price leadership, setting prices up the chain to fishers, and down the chain to retailers. Lastly, marketing margins between beach, wholesale and retail prices are relatively large compared with other fish products (although these comparisons are made with fresh product rather than live product).

These relatively high marketing margins, and price leadership by wholesalers, are not evidence of market power. In low-technology export-oriented fisheries with distant demand centres such as the live reef food fish trade, the market chain must, by necessity, be quite extended (Muldoon and Johnston 2006). This translates to relatively high costs of transport and marketing (MacFadyen et al. 2003, Rola-Rubzen and Hardaker 2006). Due to the large distances to export hubs and markets, and the need to retail the product alive, the main capital costs are the construction of sea or land-based holding facilities by traders and exporters. The main distribution costs incurred by downstream agents are the costs of holding and transporting live reef food fish to consumer markets in Hong Kong. Overall, agents further along the market chain incur considerably higher capital and distribution costs than do the primary producers (fishers and middlepersons) and as such, they carry considerably higher risk of loss of returns from

**Figure 2: Beach prices (aggregated across all countries of origin) and wholesale prices (in Hong Kong) aggregated across nine key restaurant species.**



mortality of the 'live' product as it traverses the market chain from primary producer to consumer markets.

Consideration of risk in the context of artisanal fisheries may not conform to traditional risk aversion behaviour. With respect to fishing effort, previous studies have shown that fishers tend to be mostly risk-averse (Bockstael and Opaluch 1983, Dupont 1993, Eggert and Tveteras 2001). These results contrast with those from artisanal fisheries in Southeast Asia where fish stocks tend to be more heavily exploited and catch rates are highly variable. Under these conditions, effort allocation of fishers tended not to be related to spatial patterns in fish abundance but rather to minimising risks through minimising operational costs (Pet-Soede et al. 2003). Moreover, the lack of alternative employment opportunities usually results in temporal allocation of fishing effort remaining constant throughout the year, regardless of fluctuations in prices (Pet-Soede et al. 2003). Price fluctuations in and of themselves however, will affect fishery returns and need to be incorporated into any analysis of how value changes are distributed along the supply chain.

The distribution of value gains from marine products is recognised as an issue of great concern in developing country export fisheries. As a high-value commodity there is a perceived potential for high economic gains along the market chain for live reef food fish. Value and profit margins need to be considered, however, in the context of costs incurred and risk borne by the respective agents along the market chain. Risk of fish mortality is usually not factored into the costs of transportation or the distribution of wealth among stakeholders. Mortality remains a major factor, however, in the cost of delivering live reef food fish to markets to Hong Kong with most fish deaths occur during the holding phase in the source country and during the transshipment phase. This may explain any inequitable distribution of value amongst agents along the market chain. *A second article in this series on marketing will be available in the forthcoming issue of Aquaculture Asia Magazine.*

## References

- Agriculture, Forestry and Conservation Department (AFCD) (2003) Report on Live Marine Fish Trade. Government of Hong Kong: Hong Kong.
- Asche, F. and Bjørndal, T. (1999) Demand elasticities for fish: A review. Available at <https://www.globefish.org/publications/specialseries/vols/Vol09/SSE0800.htm> as at July 2003.
- Asche, F., Gordon, D.V. and Hannesson, R. (2004). Tests for market integration and the law of one price: the market for whitefish in France. *Marine Resource Economics* 19: 195-210.
- Asche, F., Hartmann, J., Fofana, A., Jaffry, S., Menezes, R. (2002). Vertical Relationships in the Value Chain: An Analysis Based on Price Information for Cod and Salmon in Europe. SALMAR Report No.2, Margins along the European seafood value chain. Impact on the salmon industry on market structures. Centre for Fisheries Economics. 111p.
- Bird, P. (1986) Econometric estimation of world salmon demand. *Marine Resource Economics* 3: 169-182.
- Bockstael N.E. and Opaluch J.J. 1983. Discrete Modelling of Supply Response Under Uncertainty: The Case of the Fishery. *Journal of Environmental Economics and Management*. 10 (2) 125-137
- Cesar, H.S.J., Warren, K.A., Savody, Y., Lau, P., Meijer, S., and van Ierland, E. (2000) Marine market transformation of the live reef fish food trade in southeast Asia. In Cesar, H.S.J. (Ed) *Collected Essays on the Economics of Coral Reefs*. Sweden: CORDIO.
- Deaton, A.S. and Muellbauer, J. (1980) An almost ideal demand system. *American Economic Review* 70: 312-326.
- DeVoretz, D. (1982) An econometric demand model for Canadian Salmon. *Canadian Journal of Agricultural Economics* 30: 49-60.
- DeVoretz, D.J., and Salvanes, K.G. (1993) Market structure for farmed salmon. *American Journal of Agricultural Economics* 79: 227-233.
- Dickey, D.A. and Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association* 74: 427-431.
- Dupont D.P. 1993. Price uncertainty, expectations formation and fishers' location choices. *Marine Resource Economics*. 86 (1) 219-247.
- Eggert H. and Tveteras R. 2001. Stochastic Production and Heterogeneous Risk Preferences: Commercial Fishers' Gear Choices. *American Journal of Agricultural Economics*. 86 (1) 199-212.
- Engle, R.F., and Granger, C.W.J. (1987). Co-integration and Error Correction: Representation, Estimation and Testing. *Econometrica* 55: 251-276.
- Fofana, A., Hartmann, J., Jaffrey, S. and Murray, A. 2003. Salmon trade between Norway, the United Kingdom and France. In P. Guillotreau (ed) *Prices and margins along the European seafood value chain - Salmar project Final Report*. Nantes, France, University of Nantes: 123-129.
- Fuller, W.A. (1976). *Introduction to Statistical Time Series*. New York: John Wiley and Sons.
- Gonzales F. Guillotreau P. and Le Grel, L. (2002). The transmission of price variability along the French cod value chain. In: *Proceedings of the XIVth European Association of Fisheries Economists Conference*, Faro, Portugal 25-27 March 2002.
- Goodwin, B.K., Grennes, T.J. and Wohlgenant, M.K. (1990). Testing the law of one price when trade takes time. *Journal of International Money and Finance* 5: 682-93.
- Granger, C.W. (1969). Investigating causal relations between econometric models and cross-spectral methods. *Econometrica* 37: 424-438.
- Granger, C.W. (1986). Developments in the study of cointegrated economic variables. *Oxford Bulletin of Economics and Statistics*, 48: 213-228.
- Herrmann, M.L., and Lin, B.H., (1988) The demand and supply of Norwegian Atlantic salmon in the United States and the European Community. *Canadian Journal of Agricultural Economics* 38: 459-471.
- Herrmann, M.L., Mittelhammer, R.C., and Lin, B.H., (1993) Import demand for Norwegian farmed Atlantic salmon and wild Pacific salmon in North America, Japan and the EC. *Canadian Journal of Agricultural Economics* 41: 111-125.
- Johannes, R. E. and M. Reipen (1995). Environmental, Economic and Social Implications of the Live Reef Fish Trade in Asia and the Western Pacific, A study for the Nature Conservancy. Noumea, South Pacific Forum Fisheries Agency.
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12: 231-54.
- Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian Autoregressive Models. *Econometrica* 59: 1551-1580.
- Johansen, S. and Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration – with applications to demand for money. *Oxford Bulletin of Economics and Statistics* 52: 169-210
- Johnson, A. Durham, C.A. and Wessells, C.R. (1998) Seasonality in Japanese household demand for meat and seafood. *Agribusiness* 14: 337-351.
- Jones, R.J., and A.L. Steven. 1997. Effects of Cyanide on Corals in Relation to Cyanide Fishing on Reefs. *Marine and Freshwater Research* 48:517-522.
- Kabir, M., and N.G. Ridler (1984) The Demand for Atlantic Salmon in Canada. *Canadian Journal of Agricultural Economics*, 32: 560-568.
- MacFadyen G., Banks R, Banks R., Phillipps M., Haylor G., Mazaudier L. and Salz P. 2003. Background paper on the international seafood trade and poverty. Prepared under the EC-PREP project (EP/R03/014), International Seafood Trade: Supporting Sustainable Livelihoods among Poor Aquatic Resource Users in Asia. Poseidon Aquatic Resource Management Ltd (UK), Network of Aquaculture Centres in Asia-Pacific and STREAM Initiative.



MacKinnon, J.G. (1994). Approximate asymptotic distribution functions for unit-root and cointegration tests. *Journal of Business and Economic Statistics* 12: 167-176.

Muldoon, G. and Johnston, W. (2006) The impact of mortality and price risk on costs and value distribution along the market chain for live reef food fish: A spreadsheet analysis. Paper presented at the 2nd ACIAR Workshop on the Economics and Market Analysis of the Live Reef Fish Food Trade in Asia-Pacific 14-16 March 2006, Penang.

Muldoon, G.J and McGilvray, F (2004) Economic and Trade issues, p 19-41 in J. Maclean and Y. Sadovy, (eds). *The Live Reef Fish Trade*. ABD Pacific Studies Series. Asian Development Bank, Manila.

Pet Soede C., van Denson W.L.T., Hiddink J.G., Kuyl S. and Machiels M.A.M. 2001. Can fishermen allocate their fishing effort in space and time on the basis of their catch rates? An example from the Spermonde archipelago, SW Sulawesi, Indonesia. *Fisheries Management and Ecology* 8 15-36

Rola-Rubzen M.F. and Hardaker J.B. 2006. Improving market access for smallholders: challenges and opportunities. Paper presented to the 50th Annual Conference of the Australian Agricultural and Resource Economics Society, 8-10 February 2006, Sydney

Sadovy, Y. (2001). The Live Reef Food Fish Trade in Hong Kong: Problems and Prospects. In: *Marketing and Shipping Live Aquatic Products: Proceedings of the Second International Conference and Exhibition, November 1999, Seattle, WA*, edited by B. C. Paust and A. A. Rice. Fairbanks: University of Alaska Sea Grant (AK-SG-01-03). p. 183-192

Sadovy Y.J., Donaldson T.J., Graham T.R., McGilvray F., Muldoon G.J., Phillipps M.J., Rimmer M.A., Smith A. and Yeeting B. 2004. While stocks last: the live reef food fish trade. ABD Pacific Studies Series. Asian Development Bank, Manila.

Sadovy, Y.J. and Lau, P.P.F., (2002) Prospects and problems for mariculture in Hong Kong associated with wild-caught seed and feed. *Aquaculture Economics and Management* 6(3/4): 177-190.

Sadovy, Y.J., and Vincent, A.C.J., (2002) Ecological Issues and the Trades in Live Reef Fishes, In *Coral Reef Fishers* Elsevier Science: USA.

Slade, M.E. (1986). Exogeneity test of market boundaries applied to petroleum products. *Journal of Industrial Economics* 34: 291-304.

Smith, P., Dennis, F., and Proctor, W. (1996) South Korean Market for Seafood, ABARE Research Report 96.3, Canberra

Tveteras, R. (1999) Production risk and productivity growth: some findings for Norwegian salmon aquaculture. *Journal of Productivity Analysis* 12: 161-179.



## Breeding ornamental gouramis

*Continued from page 14.*

100-150 larvae can be reared easily in a small aquarium of 80 x 40 x 40 x cm size. The aquarium should be installed with thick aquatic weeds and be provided with sufficient space for their movement.

We observed length-weight relationship of *Colisa fasciata* and *Colisa lalia* caught from different aquatic habitats of Assam as  $W = 2.432 L - 16.475$  and  $W = 0.319 L - 5.567$  respectively.

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