Asia-Pacific Marine Finfish Aquaculture Network

Magazine

Contents

First Breeding Success of Napoleon Wrasse and Coral Trout

Sih Yang Sim (editor)

The Research Institute for Mariculture – Gondol, Bali, Indonesia - has successfully bred Napoleon wrasse, a premium species in the live reef fish market, commanding prices as high as US$100 per kg. Captive breeding of Napoleon wrasse has long been one of the "holy grails" of marine fish culture and NACA and the APMFAN congratulates the Gondol researchers in achieving this breakthrough. Many others have tried, but this is the first reported success.

The spawning took place around December 2003, via combined hormone treatment and environmental control. Larviculture is still at a very early stage and survival rate of the larvae is currently low. The larvae have a small mouth so first feeding is still the main issue to be tackled. SS-rotifer seems to be a suitable first feed for Napoleon wrasse.

So far (April 17, 2004) around 100 small juveniles have survived at around 2-3 inches. The growth rate for this species is very slow; at 5 months old the fish only reach a maximum of 3 inches. However, slow growth is a common issue when a new species is bred for the first time, and will likely improve as the nutritional needs of this species are better understood.

Researchers at Gondol have also had some success in breeding coral trout (*Plectropomus leopardus*). The spawning took place in January 2004 and by April 2004 around 100

More photographs overleaf...

Handling male Cheilinus undulatus broodstock.

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fingerlings of 2 inches are kept in the research facility. Similar to Napoleon wrasse, coral trout also have small mouths and require very small first feed, such as SS-rotifers.

Canulating female *C. undulatus* broodstock

Above / below: Coral trout broodstock (*Plectropomus leopardus*) from the Gondol Research Institute for Mariculture. Coral trout can change colour in just a few seconds. In the wild they usually adopt a smooth, even tone while swimming (which may be light or dark, depending on their surroundings). They swiftly shift to a disruptive pattern with spots and saddles when threatened, or when settling on the bottom to ambush their prey.

Marine Finfish Aquaculture Magazine

An electronic magazine of the Asia-Pacific Marine Finfish Aquaculture Network

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Welcome to the magazine

Issue 1, 2004 (April-June)

Welcome to the new quarterly Asia-Pacific Marine Finfish Aquaculture Magazine. This is a new publication of the Asia-Pacific Marine Finfish Aquaculture Network (APMFAN), coordinated by NACA, in cooperation with ACIAR, APEC, Queensland DPI&F, and SEAFDEC Aquaculture Department.

This magazine builds on the successful electronic newsletters of the marine fish network. The regular marine fish “eNews” will continue, complemented with this new “e-magazine”. The magazine provides the opportunity for researchers, development projects, and industry, to share experiences and report progress in research and development of marine fish aquaculture in the Asia-Pacific region. The editors welcome articles on breakthroughs in marine fish culture research, case studies of successful development initiatives, examples of better farming and marketing practices, and other interesting new developments.

In each edition the magazine emphasizes different themes in marine finfish aquaculture. This edition provides an update on recent progress in marine fish hatchery and nursery development. Future editions are planned on marketing, trade and economics, nutrition and feeding, and environment and health themes.

The next issue of the magazine will be focused on markets and trade in marine fish, and the economics of marine finfish farming in Asia. If you would like to contribute to the magazine, please send your article – short or long – to the editors at the address in the side panel. Contributions are very much appreciated.

The Editors

Above: And here they are...the world’s first hatchery-reared Cheilinus undulatus fingerlings. Below: Hatchery-reared juvenile coral trout.

Above and below: Live reef fish holding facilities for the export trade

Regional Developments & Update

Sih Yang Sim

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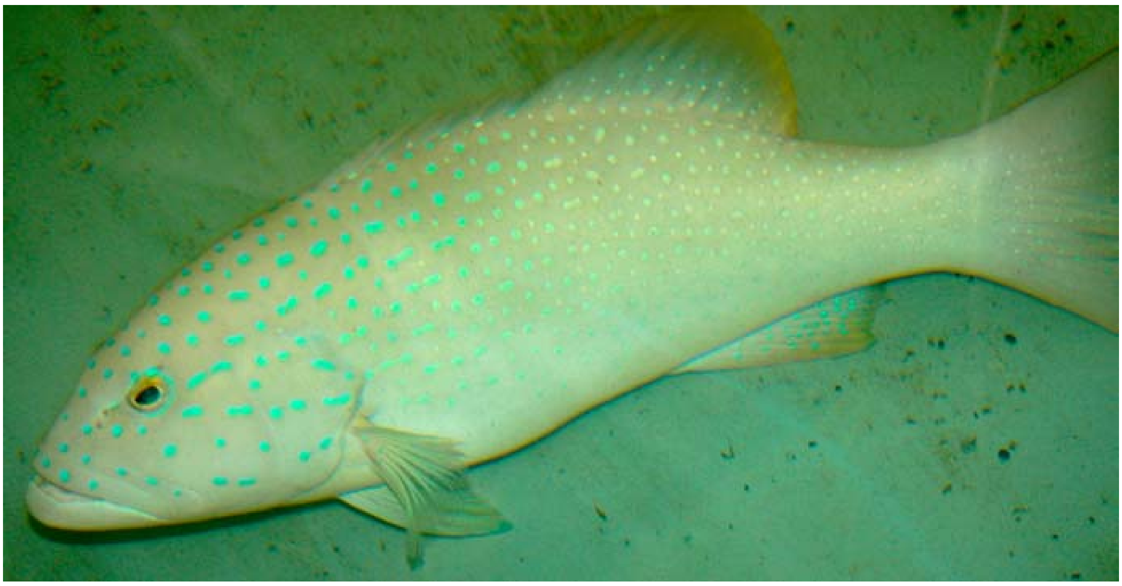
With recent progress in grouper hatchery and nursing technologies and techniques, hatchery reared groupers are increasingly contributing to the aquarium trade or grow-out industries. Training in grouper hatchery and nursing technologies has been one of the activities of the Asia-Pacific Marine Finfish Aquaculture Network through the coordination of the Network of Aquaculture Centres in Asia-Pacific (NACA) in cooperation with Northern Fisheries Center, Queensland, Australia (QDPI) and Research Institute for Mariculture-Gondol (RIM-Gondol). Two regional grouper hatchery training courses were conducted in 2002 and 2003. The support for this training came from the Ministry of Marine Affairs and Fisheries, Indonesia, the Network of Aquaculture Centres in Asia-Pacific (NACA), the Australia Centre for International Agricultural Research (ACIAR), the Asia-Pacific Economic Cooperation (APEC) and the Japan International Cooperation Agency (JICA). The training courses have successfully trained 28 people from 10 countries, with some trained participants already reporting success in grouper fingerling production and improved hatchery techniques, from Australia, India, Malaysia, Thailand and Vietnam.

Indonesia has been leading in the production of mouse and tiger grouper fingerlings, with most of these fingerlings now supplying domestic grow-out. This development is due to the increasing focus on marine finfish aquaculture development in Indonesia by the government. However, increasing concern also been raised for the quality of seed produced from some of the hatcheries in Indonesia. There are some 50 and 3 grouper hatcheries in Bali and Lampung respectively. Although some other species of groupers such as *E. coioides* and *E. polyphekadion* are also reported to be produced, the commercial interests are not strong. *E. coioides* fetches a lower price and wild fingerlings are abundant, so hatchery operators are not expressing strong interest. While for *E. polyphekadion*, although it commands a relatively higher wholesale price in Hong Kong (US$25) and Southern China (US$27) markets, the fact is that it grows very slowly for grow-out stage, and economic returns become a problem for small-scale farmers who do not have strong cash flow.

Recently, preliminary success in *Plectropomus* spp. breeding is also opening up a new potential for these species to be produced in hatcheries. Although at an early stage of research and development, promising results have been archived in Indonesia and Thailand. *Plectropomus maculatus* has been reported to be produced in Lampung, Indonesia (Ref: Marine Finfish Aquaculture Newsletter No. 6, July-September, 2003) while *Plectropomus leopardus* was been produced in Trad, Thailand (Ref: article below). Both places are government research facilities and the number of fingerlings produced is still relatively low, about 100 and 49, respectively. Many research institutes in the region also targeting *Plectropomus* spp. as part of their grouper breeding programs.

Increasing research interest is focusing on the CITES listed species of Napoleon wrasse (*Cheilinus undulatus*). Several countries, such as Indonesia, Malaysia and Thailand are collecting broodstock and aiming at breeding this species in captivity.

Other high value species, such as tuna are also moving toward hatchery technology development. A large tuna hatchery facility in Indonesia was completed in 2003 and collection of yellowfin tuna broodstock has been achieved. Breeding trials are expected to begin in 2004.



Plectropomus maculatus at the Trad Research Station, DOF, Thailand. Photo by Hassanai Kongkeo.

A Guide to Small-Scale Marine Finfish Hatchery Technology

The guide provides an outline of the requirements to establish a small-scale marine finfish hatchery, giving attention to both technical and economic aspects. It is intended to provide sufficient information for potential investors to decide whether investment in such ventures is appropriate for them. The guide provides some basic technical information to help indicate the level of technical expertise necessary to operate a small-scale marine finfish hatchery. It is not intended as a detailed technical guide to the operation of small-scale hatcheries but additional information sources on technology, including training courses are provided.

This guide has been written by a team of experts in marine finfish aquaculture who have been involved in a multinational collaborative research project since 1999. This research project *Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region*, funded by the Australian Centre for International Agricultural Research (ACIAR), has made an important contribution to improving the sustainability of marine finfish aquaculture by improving hatchery production of high-value species, particularly groupers.

The second phase of the ACIAR project will commence in July 2004 and information and progress on this project will be available from the project web site: http://www.enaca.org/grouper/

Thailand Success in Culture of Coral Trout (*Plectropomus leopardus*)

(Based on a translation of an article in the agriculture & scientific column, Thairath Newspaper, 9th March 2004 by Mr. Hassanai Kongkeo)

Blue-spotted grouper is the Thai local common name of coral trout. There are many species and families of grouper with different sizes varying from 5 cm up to 200-300 kg. Groupers in Thailand are usually named after their appearance such as red-banded, duskytail, yellow, greasy, green eye, humpback, etc. Due to their high value in both domestic and export markets, scientists have been attracted to conduct research on artificial breeding and culture. There has been success with some species such as *E. coioides*.

It is locally believed that eating leopard coral grouper will have aphrodisiac effects, creating high demand for this fish in local markets with prices of up to Baht 800-1,000/kg. This in turn has led to overfishing and fishermen have reported difficulty in catching this fish over the past 1-2 years.

Mr. Thawat Sriveerachai, Chief of Trad Coastal Aquaculture Station of the Department of Fisheries reported that research carried out in Trad has provided information on the life history and behaviour of coral trout. This species is easily frightened, lives in very clean water, and the larvae feed on very tiny aquatic organisms. He collected wild fish with assistance from offshore fishermen and now there are 20 broodstock available in the Trad station.

An artificial breeding programme commenced at Trad station in 2002. The first spawning occurred in July 2003 but the newly hatched larvae only survived three days. A second batch was spawned in August 2003, and this time larvae only survived six days. Another 17 trials had been conducted up to October 2003.

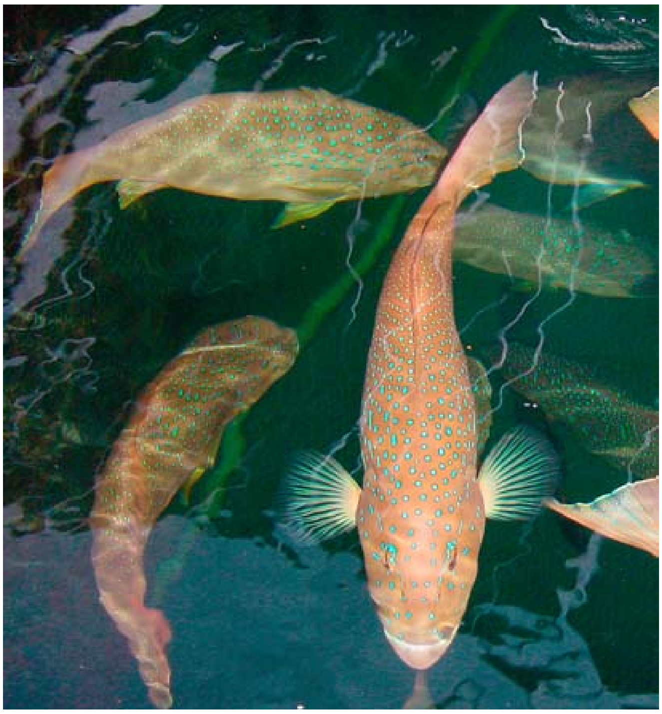
The first successful batch yielded 49 surviving fingerlings at 100 days with average of 6 cm body length and 3.5 g body weight. It is accepted that 100 day fingerlings have passed the critical juvenile period. This is the first success in Thailand for breeding of this grouper.

Indonesia Pushing for Commercial-scale Grouper Farming

Indonesia has been leading the region in production of grouper fingerlings, particularly for mouse and tiger grouper. This success has in part been due to support from grouper projects by organizations such as ACIAR & JICA to the Research Institute for Mariculture – Gondol since 1999. Mass production of hatchery techniques for these two grouper species are now relatively well developed and have been adopted by small-scale hatcheries, however larger scale operations are also increasingly emerging.

Indonesia is expecting to see grouper aquaculture accelerate over the next few years. The government research centers, located at Gondol, Lampung and Surabaya, are playing key roles in providing technical support to the industry as well as supplying eggs, fry and fingerlings to the industry. There has been a lot of development in Lampung Bay, South Sumatra for grouper grow-out, particularly cage culture operations.

However, development of the industry is not without problems and constraints. Diseases such as VNN and iridovirus have been causing mass mortality at hatchery and grow-out stages. In addition, parasitic diseases (benedenid monogeneans and *Cryptocaryon* sp.) are also major issues. There is increasing concern about the possibility of spreading these diseases to wild grouper populations.



Coral trout broodstock at Lampung station. (Photo: S.Y. Sim)

However, protocols are being developed to reduce the risk of these diseases and their economic impacts.

Continued research on formulated feed for grouper grow-out is been carried out in RIM-Gondol. The second phase of the ACIAR Project "Improved Hatchery and Grow-out Technology for Grouper Aquaculture in the Asia-Pacific Region" will commence in the second half of 2004 and this 3.5 year project will continue to support the development of the formulated feed for grouper aquaculture.

Some research activities have been prioritized by the Indonesian government including focus on the development of reliable methods and techniques for improving nutrition (live feeds; feeding of larvae, fingerlings, juveniles and broodstock) and disease control. Genetic improvements and disease resistance are also come under consideration.

A further proposal from the Australian Institute of Marine Science and Indonesia's Directorate of Aquaculture on GIS/Database computer models to identify best sites for aquaculture and mariculture along the Bali coastline is currently also under consideration for funding by ACIAR.

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Indonesia Gearing up for Yellowfin Tuna Breeding

The Research Institute for Mariculture–Gondol (RIM-Gondol), Bali, Indonesia began constructing a yellowfin tuna hatchery facility in 2001, which was completed in 2003. At the NACA TAC 7 meeting, July 2003, a field trip was arranged to visit RIM-Gondol facilities which had already started to collect yellowfin tuna broodstock for their breeding program.

In early 2004, at a press conference Dr Adi Hanafi (Director of RIM-Gondol) stated that RIM-Gondol currently has 43 yellowfin tuna broodstock in the holding tanks, and they are expecting to conduct the first spawning trial in June 2004.

This yellowfin tuna project is partly funded by Overseas Economic Cooperation Fund (OECF) of Japan in a four year project with the objective to successfully spawn, fertilize and hatch yellowfin tuna in captivity. If breeding is successful, this may bring farming of yellowfin tuna to commercial farmers in Indonesia.

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Gemma Micro – Leaving Artemia Behind

Trine Karlsrud

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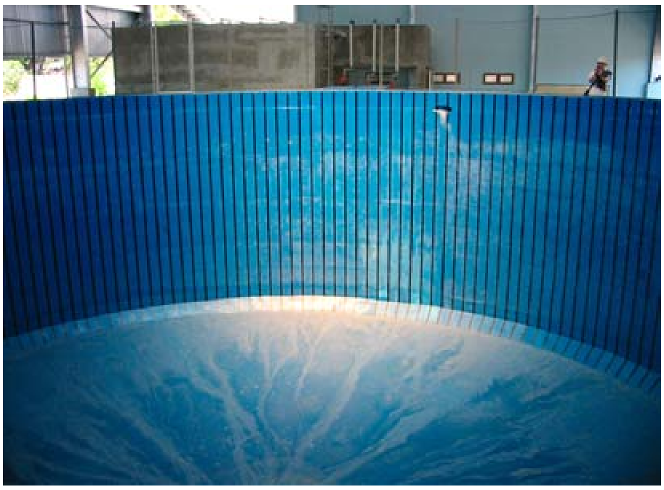
A novel technology is employed for making Gemma Micro and this article outlines some of the concepts and results behind that product.

Production of marine fish juveniles in commercial hatcheries still depends on the supply of live feed. Until now, dry feed substitution for live feed (weaning) is only performed after some weeks of life in marine fish hatcheries. Weaning is crucial for lowering production costs and to meet the demand for high and constant quality juveniles.

As cultivated live feed is similar to natural plankton, this can have some advantages for example; live feeds stimulate feeding behaviour by chemical and tactile cues. Cultivated live feed is not optimal, as it needs to be enriched to meet the nutritional requirements of larvae. Moreover, quality of live feed is variable, and use carries microbial risks. From a practical point of view, live feed requires separate biological production systems to that of larval rearing. This increases the complexity and uncertainty of juvenile production and

Above: The tuna hatchery situated on the bay. Below: One of the huge tuna broodstock tanks (Photo: S.Y. Sim)



40 days old sea bream larvae fed Gemma Micro

from an economic point of view, live feed supply and purchase price both vary widely.

One of Skretting's products launched in 2003 for marine fish is Gemma Micro, a feed developed to replace *Artemia* in most marine fish larvae (barramundi, yellowtail, grouper, etc.). Developed by INRA/IFREMER Skretting in France started the exclusive manufacture of Gemma Micro on a commercial scale from summer 2001. Both laboratory and commercial tests have given very good results (growth, survival and improved development) for several marine fish species.

Gemma Micro has some revolutionary thinking behind it: it corresponds to the specific requirements of marine fish during very early development. The INRA/IFREMER Nutrition team studied digestive enzymatic activity onset during larval development. These studies defined optimal protein, dietary fat and phospholipid levels both from the quantitative and qualitative points of view.

202,000 barramundi (Lates calcarifer) weaned larvae were produced using Gemma Micro with minimum use of Artemia at Darwin Aquaculture Centre in Australia

Jerome Bosmans and his team at Darwin Aquaculture Centre, Northern Territory Fisheries, in Australia, have recently tested Gemma Micro in barramundi larvae. Larvae were stocked in two square 5-ton intensive recirculated tanks (water exchange of 15-30 %/hour, water temperature of $29.5-30^{0}C$) at a density of 80 larvae per liter.

Photoperiod was 12 hours/day. Both the experimental and control tanks were fed rotifers only from 36 hours post-hatching until day 5. Then the experimental tank (Gemma Micro) was fed Gemma Micro and rotifers until day 12 when a small amount of *Artemia* was introduced with Gemma Micro. The control tank (Control) was fed employing the standard weaning protocol using rotifers, *Artemia* and a commercial weaning diet. *At day 25 larvae fed Gemma Micro were on average 35 % bigger than larvae in the control tank (Figure 1).*

In the experimental tank only one can (0.44 kg) of *Artemia* was used to wean 202,000 fish using Gemma Micro. This means that *only* 2.2 kg of *Artemia* was used per million larvae weaned over the larval rearing period (20-30 kg *Artemia* per million larvae is considered to be excellent in similar systems using the standard weaning protocol).

On the basis of results obtained in this trial, Jerome Bosmans is now confident that they can completely eliminate the use of *Artemia* in their intensive larval rearing system.

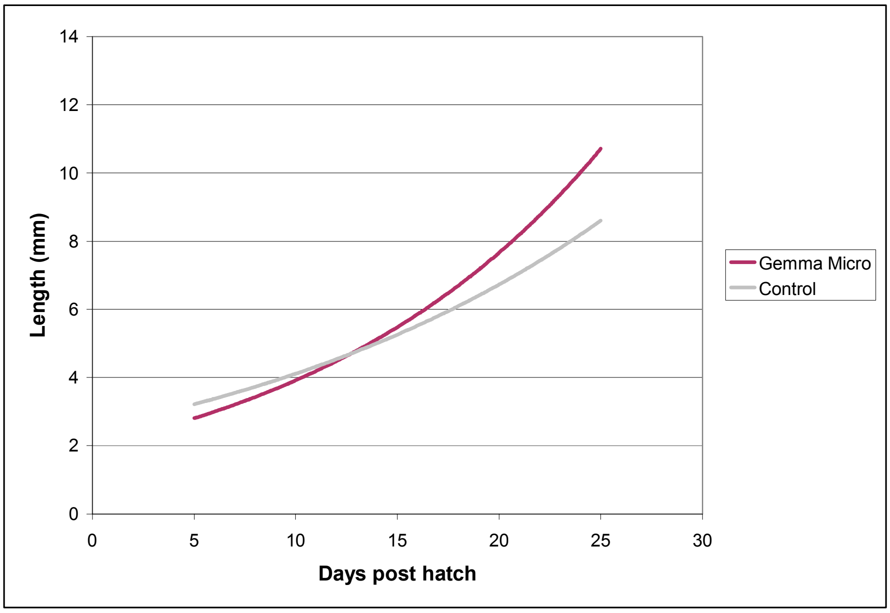
28,000 barramundi juveniles (Lates calcarifer) were produced without any Artemia *in Indonesia*

At Fega Marikultura located in Jukung Island, Pulau seribu, Indonesia, barramundi larvae were reared using *only* Gemma Micro - no *Artemia*.

One 10 m^3 tank was stocked with about 100,000 2-day old barramundi larvae. The experimental tank was fed rotifers and Gemma Micro until day 9 (larvae length about 4 - 4.5 mm), while the control tank was fed only rotifers. The larvae in the experimental tank showed normal feeding behaviour and microscopic analyses showed that larvae had feed in their digestive system. The results showed that larvae fed rotifers and Gemma Micro grew better than larvae in the control tank.

On day 9 the experimental tank was split into two (experimental and control) 10 m^3 tanks by siphoning. The experimental tank was fed Gemma Micro followed by routine weaning diet, while the control tank was fed *Artemia* followed by routine diet until day 25. It was observed that larvae in the experimental tank became brown (a sign of metamorphosis) at 8 mm length compared to 11 mm length in the control tank. This is clear proof of the superior nutritional value of Gemma Micro compared to *Artemia*. At the end of the experimental period (day 25), they counted 28,000 high quality barramundi juveniles. The survival rate was the same in both the experimental and control tanks.

Figure 1 - Relationship between average length (mm) and days post hatch for larvae fed Gemma Micro and the control tank



6 day old barramundi larvae (photo: Sagiv Kolkovski)

Conclusion

Gemma Micro has really proved itself as an effective *Artemia* replacement diet for barramundi and a number of other marine species. This will prove a valuable tool for the marine hatchery wishing to reduce costs, improve quality and to put juvenile production onto a more convenient and cost-effective footing. Gemma Micro will give marine fry a 'flying start' and provide a valuable foundation for the next feed in Skretting's product range: Gemma.

For more details please contact the author Trine Karlsrud at Skretting in Australia trine.karlsrud@nutreco.com.

Editors note: We do not endorse any commercial product, the article is merely the view of the author.

Reference

Skretting Outlook Magazine, Number 19, Spring 2003 pp. 7 - 10.

Hobas...continued from page 19

a skill enhancement programme for shrimp farmers in Sri Lanka (Drengstig *et al*. 2004). This project focuses on communicating Codes of Practices and Best Management Practices, and to facilitate a practical implementation of such voluntary standards among farmers in Sri Lanka. It is beyond all doubts that more efficient technology in combination with an improved understanding of these complex systems will contribute to a more viable shrimp farming industry.

Moreover, NIVA, RF and HOBAS is also cooperating in a major R&D project in India together with the National Institute of Oceanography (NIO), Goa were the HOBAS technology is being tested under commercial conditions. Finally, the HOBAS technology is being tested in Spain under commercial terms for production of the carp tench (Tinka tinka) in earthen ponds. The technology seems highly suitable for pond farming either in brackish or freshwater systems producing fish or shrimp.

Note: Cited references are available from the corresponding author.

Report of the Komodo fish culture project

Trevor Meyer MSc & Peter J. Mous PhD

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A pilot project to establish a multi-species reef fish hatchery in Loh Mbongi and village-based grow-out farms in communities surrounding Komodo National Park, West Flores, Indonesia. Report from The Nature Conservancy, Southeast Asia Center for Marine Protected Areas in collaboration with the Komodo National Park authority.

The main objective of the fish culture project is to provide sustainable fish culture as an alternative livelihood to non-sustainable fishing practices in and around Komodo National Park. A secondary objective relates to the Hong Kong based trade in live reef fish. Currently, the live reef fish trade is rapidly depleting the Indo-Pacific stocks of Napoleon wrasse (*Cheilinus undulatus*) and groupers (Serranidae). It is hoped that the Komodo fish culture project can demonstrate how fish culture of groupers can be done in a sustainable and environmentally sound manner, thereby contributing to the market transformation of the live reef fish trade from unsustainable, capture-based to sustainable, culture-based.

The Komodo fish culture project aims to involve local communities in the grow-out of estuary grouper *Epinephelus coioides*, mouse grouper *Cromileptes altivelis*, tiger grouper *Epinephelus fuscoguttatus*, sea bass *Lates calcarifer* and mangrove jack *Lutjanus argentimaculatus*, which can be marketed as live product to the Hong Kong - based live reef fish trade.

Fingerlings are produced from captive broodstock in a hatchery situated in Loh Mbongi (ca. 6 km North of Labuan Bajo). The pilot project aims to produce 25 tons of live fish yearly, to be realized over 3-4 harvests per year per grow-out unit. A grow-out unit consists of a complex of 16 floating cages, varying in size between nine and 25 m^2 surface area. In the pilot phase, four grow-out units will be deployed near the villages that are participating. The produced volume will consist of a mix of the five species for which broodstock is presently secured. This multi-species approach reduces risks related to species-specific vulnerability to disease and to fluctuation in consumer preference and price. The species composition of initial batches of fingerlings will depend on hatchery practicalities, as this batch will be used for training in grow-out in village-based fish farms rather than for the generation of revenue.

In the pilot phase (i.e. production capacity of 25 tons annually) the project will involve ca. 20 villagers on a full-time basis, but many more will be trained in grow-out techniques. Once economic viability and environmental sustainability have been demonstrated, a carrying capacity analysis will be carried out to determine the optimal production capacity, after which a private business partner will be invited to upscale and develop the project into a triple bottom-line business – economically viable, socially responsible and environmentally sound.

As culturing of grouper still poses some technical challenges, the fish culture project created partnerships with institutes that can provide the necessary know-how. The main partners in the Komodo fish culture project are the Research Institute for Mariculture in Gondol (Bali, Indonesia), the Department of Primary Industries & Fisheries, Queensland (Australia) and the Network of Aquaculture Centers in Asia-Pacific (NACA).

By March 2003 construction was completed, and the hatchery at Loh Mbongi was officially inaugurated in July 2003 by the Minister of Fisheries and Marine Affairs of Indonesia. This event was attended by senior local government officials and key stakeholders.

Full operational capability of the hatchery was reached by March 2003. The first batch of eggs that were transferred from the broodstock facility to the hatchery were of estuary grouper, collected during March 2003. Larval survival reached 3.7%, an encouraging result for the first production. This batch had been successfully stocked into grow-out cages by June 2003 and had reached an average weight of 350g by February 2004. Since hatchery production commenced, all of the five species of fish maintained at the Komodo Fish Culture Project have been successfully reared to the grow-out phase.

Hatchery production, however, has not been without its challenges, and survival rates have varied considerably. To date, the best survival rate achieved has been 7.6%, for a batch of mouse grouper produced in July 2003. During July 2003, a batch of 20,000 mouse grouper were reared in the nursery, representing the first production of a commercial-sized batch by Loh Mbongi.

An assessment of suitable sites for the installation of cage fish farms around the Komodo area was completed by the end of October 2002, with the most suitable sites being found close to the villages of Boleng, Medang, Sape and Menjaga. Subsequently, other suitable sites have been identified at Warloka and close to Pulau Misa. At present, no aquaculture development is envisaged within the national park boundaries.

The first of the four planned community grow-out units was installed and stocked with fish during December 2003, in the village of Warloka. This site was chosen due to the considerable interest shown by the community in involvement in the Fish Culture Project, and by its suitability for cage culture.

Cromileptes altivelis fingerlings produced at Loh Mbongi

Community members of all targeted villages have visited the facility at Loh Mbongi and discussed the aims of the Fish Culture Project. To date, most have shown considerable interest in the project, and efforts are now underway to install the second community-based grow-out unit.

The Komodo Fish Culture Project is now entering its most critical phase, that of its transfer to a private business partner, to allow for its upscaling to a commercially viable business. The pilot project has demonstrated the viability of community-based grouper culture in the Komodo region, and a massive demand for hatchery-reared juvenile grouper and snapper exists in eastern Indonesia at the present time. Existing Indonesian commercial hatcheries are unable to meet this demand.

The Komodo Fish Culture Project is currently seeking a business partner to assist in the transformation of this pilot project to a financially sustainable enterprise, whilst conforming to the primary project aims of social responsibility and environmental soundness. All interested parties are invited to contact Dr. Peter J. Mous (Science and Training Manager) or Mr. Trevor Meyer (Mariculture Manager).

Conclusion of Research on Capture and Culture of Pre-settlement Fish for the Marine Aquarium Trade in Solomon Islands

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Between February 1999 and December 2003 the WorldFish Center, Solomon Islands, carried out research on a new artisanal fishery based on the capture and rearing of pre-settlement coral reef fish (Hair et al. 2002). This work was funded by the Australian Centre for International Agricultural Research (ACIAR). Environmentally friendly methods (light traps and crest nets) were used to capture postlarval fish as they settled from the plankton. Simple aquaculture techniques were used to grow these fish to marketable size. The key factor is that fish are plentiful at this stage of their life cycle, but high mortality accompanies the transition from a planktonic to benthic lifestyle (i.e. settlement) (Doherty et al. 2004, Phillips et al. 2003). By harvesting fish immediately prior to or at settlement, adequate numbers of pre-settlers can be taken for aquaculture without affecting natural replenishment to the reefs since the large majority of those harvested would not have survived to adulthood anyway. The new fishery can therefore assist in addressing concerns of over-fishing for marine ornamentals (Sadovy and Vincent 2002, Wabnitz et al. 2003) and has potential to provide a vital source of cash income for coastal communities in the Pacific and Asian regions.

In the first phase of the research light traps and crest nets sampled postlarval supply for a week before and a week after the new moon every month from October 1999 to September 2001. Light traps were deployed in shallow water near submerged reefs and predominantly sampled competent, positively phototactic pre-settlers (Doherty 1987). Crest nets were set behind the surf zone on a shallow reef to capture fish passing between oceanic and lagoonal habitats (Dufour 1993). Very few species of value to the live reef food fish trade were recorded but ornamental species comprised 15% and 5% of the light trap and crest net catches, respectively. Only one species, lobster (*Panulirus* sp.) showed any seasonal trend in settlement rate, being more common from June to September in both years. Grow-out to market size was initially done in land-based concrete raceways, but later in sea-cages as this is a more appropriate technique for a village situation. Growth and survival of all teleosts (i.e. fin-fish) improved when rearing was transferred to floating sea-cages, although survival of crustaceans was higher in stationary, benthic cages. Fish and crustaceans were fed small amounts of minced fish, fish roe, crustacean and mollusc meat – items readily available in a coastal village.

In the first phase of the study a suite of species suitable for capture, rearing and sale to the marine aquarium trade were identified. Surprisingly, although the study originally proposed to catch and rear teleosts, banded cleaner shrimp (*Stenopus* spp.) and lobster (*Panulirus* sp.) were the most valuable component of the catch in Solomon Islands. Crest nets were chosen as the method with most potential for an artisanal fishery as they caught significant numbers of high-value crustaceans, yet were relatively cheap and simple to build and operate. Unfortunately, mortality in the nets was very high because animals caught in the soft cod-end either dried out at low tide or were crushed against the mesh during strong current flow. The second research phase was carried out in 2003 with the principle aims of (i) developing a cheap and simple "fish-friendly" harvest method for village use (based on the crest net); and (ii) developing ways to enhance survival and growth rates of fish in sea-cages.

Several modifications of the crest net were tested in an effort to improve survival at capture. The cheapest and most versatile of these comprised a cod-end constructed from a plastic bin or wooden box with mesh sides and roof. The solid cod-end retained water at low tides and provided shelter for fish during strong currents. Fish were guided into the cod-end via a hand-sewn, knotless 3 mm mesh net attached to the front of the box (Fig. 1). The effectiveness of the new "fish friendly" cod-end was well demonstrated by the improved survival rates: teleosts increased from 5 to 64%, shrimp from 10 to 97% and lobster from 85 to 97%.

A novel technique used to boost catches of lobster pueruli in 2003 was coconut logs drilled with holes (Fig. 2) and deployed in approximately 2 m depth on the reef flat behind the crest nets. The logs were a modified form of a fishing method used in Vietnam (K. Williams, pers. comm.). This was the first time the method had been used in the Pacific and it was very successful. The log collectors were mostly occupied by clear pueruli, although occasionally a pigmented puerulus was recorded. Logs were checked every morning during the new moon sampling periods of July, August and September 2003. During August, the peak recruitment month for lobster, abundance in the crest traps and logs was the same (mean = 1.8±0.3 se per device per night). The highest overnight log catch was 31 pueruli (mean = 6.0±1.7 per log). Floating artificial seaweed puerulus collectors were also deployed during the lobster recruitment season but were unsuccessful, possibly due to insufficient conditioning or strong currents.

Efforts to enhance the survival and growth of valuable species through improved grow-out techniques had mixed results. Banded cleaner shrimp were the most abundant and valuable species collected. With careful handling they were easily kept in good condition between collection at the reef crest and transfer to their grow-out habitat. Rearing cleaner shrimp was problematic due to fierce intra-specific aggression. All attempts to grow them en masse resulted in poor survival (12-60% in three weeks); the best survival was achieved through growing them individually in jars (80-100% in four weeks). The highest survival and growth were obtained in jars that were painted black to reduce exposure to sunlight that caused algal growth on the exoskeleton. The jar-rearing technique, however, was only suitable for *Stenopus hispidus* (banded cleaner shrimp). Two of the less abundant but higher-value species of banded cleaner shrimp, *S. zanzibaricus* and *S. tenuirostris*, survived but did not grow well in jars. Future work will investigate whether a combination of jar culture to nurse them through the first week, followed by rearing on an artificial reef is more appropriate for these species. Lobster were generally easy to rear and were successfully grown en masse in cages on the seafloor as long as sufficient food was provided (average survival was greater than 70% over three weeks). Problems with teleost grow-out were experienced due to the location of the sea-cage in deeper, exposed water. Small fish in the floating cages were subjected to strong currents moving through the nets and further disturbance in rough seas, forcing them to swim vigorously for extended periods to maintain their position in the water column. During rough sea conditions, mortalities in sea-cages were higher than in

Figure 1: Larvae trap

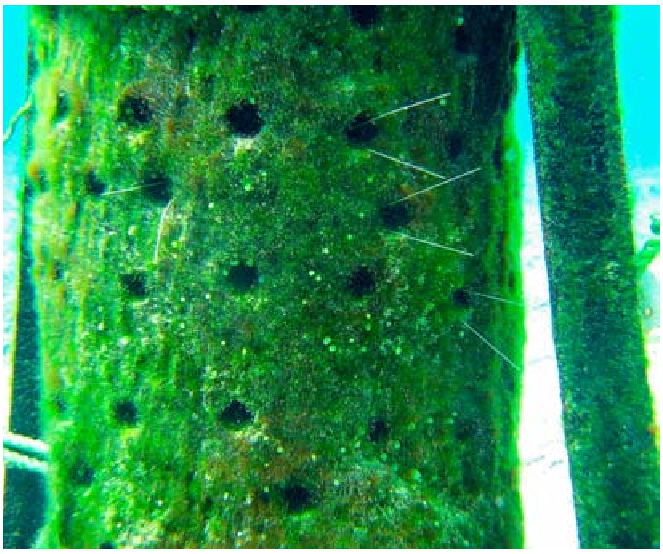

Figure 2: Lobster pueruli trap

calm weather. A fixed sea-cage in shallow, sheltered water near-shore is proposed as a more acceptable alternative.

A draft manual explaining how to catch and rear these species has been produced and the methodology will be proposed for Marine Aquarium Council approval under the Mariculture Standards that are to be drafted soon (P. Holthus, pers. comm.). A computer model of the fishery using estimated start-up costs, production (calculated from three years of fish collection) and local farmgate prices indicated that a fishery for marine ornamental species based on pre-settlers is economically viable. Furthermore, similar fisheries are operating commercially in other areas of the Pacific (Dufour 2002, X. Neyrat pers. comm.). The Solomon Islands artisanal model is based on fishing with two crest traps that would sample a total of three metres of reef. However, these methods are yet to be tested in a village situation and at a profitable scale (i.e. production of 200-300 high-value animals per month). A new project to support aquaculture development in the Pacific is commencing in early 2004. The project, funded by ACIAR and run jointly by Queensland Department of Primary Industry Northern Fisheries Centre, Secretariat of the Pacific Community and the WorldFish Center, will oversee transfer of the postlarval fish capture and culture technology to a demonstration farm in a Solomon Islands' village. This exciting stage of the work will be the ultimate proof of the feasibility of the new fishery. The draft manual will be rewritten to reflect the lessons learned during this process and be made available to assist in adoption of the techniques by other Pacific Island and Asian countries.

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Seed Production of Sand Bass (*Psamoperca weigensis*)

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The Fisheries University of Nha Trang, Vietnam, with funding support from the "Support to Brackish and Marine Aquaculture Component (SUMA)" component of the DANIDA/Ministry of Fisheries Sector Program Support has successfully produced the seed of sand bass (*Psamoperca weigensis*, Cuvier & Valennciennes). The local names for this fish in Vietnam are "ca chem mom nhon" (pointed snout fish) or "ca thay boi" (fortune teller fish). The species belongs to the Centropomidae family and is found in Indopacific region. In the wild, it lives in schools near coral reefs, in bays or associated with seaweed or sea grass in lagoons. This fish has a good taste with a price in Vietnam of around USD 5-6 / kg.

The experiment involved a total of 34 broodstock collected from the wild. Two females and two males were reared in a 12m^3 tank with the following water quality - salinity 22-34 ppt, temperature 22-32^{0}C, pH 7-8.9, with tank is aeration.

Broodstock were injected with the hormone LRHa. The fertilized eggs are around 0.8 mm in diameter. They were incubated in a tank with water temperature between 28-29^{0}C, salinity 33-35 ppt and pH 7.6-7.8. The eggs hatched after 14 hours and the hatching rate was 86%.

The larvae were reared in tanks ranging from 200 litres, 2 m^3, and 12 m^3. *Nanochloropsis occulata* was mass produced in 1 m^3 volume containers for rotifers that were enriched with squid oil before being used to feed larvae.

The density of rotifer used for various stage of larvae culture was as follows:

- 3 rotifers/ml for larvae of 1.5 days age
- 3-5 rotifers/ml for larvae of 2.5–9 days age

The fish larvae were fed with *Artemia* nauplii and rotifers from 10 to 50 days old. Artificial feed was used from 51 day onwards. The growth rate of fish is slow, around 0.04-0.06 cm/day and the survival rate to 50 days around 5.8 %.

Fingerlings of 50-51 day old were nursed both in earthen ponds and floating cages. Fish reared in cages were found to do better than in ponds. The conditions in rearing ponds were as follows:

- Salinity – 27-30 ppt
- Temperature – 30-38°C

- pH 8-8.5
- Fish stocking density - 40/m^2
- Feeding - trash fish (4 times/day, 20-40% of fish weight)
- Survival rate from stocking - 50% (4 months)

The conditions in floating cages were as follows:

- Salinity - 35-36 ppt
- Temperature - 27-29°C
- PH - 7.9-8.5
- Density - 30/m^3
- Feed - trash fish and artificial feed
- Survival rate - 70% (4 months)

The success of seed production of sand bass will enable farmers in Khanh Hoa coastal area and other places in Vietnam to have the opportunity to culture another valuable marine fish for seafood markets.

ACIAR Project "Improved hatchery and grow-out technology for marine finfish in the Asia-Pacific region"

The second phase of the ACIAR marine fish project has been approved and is due to commence in July 2004. The project will continue to support the Asia-Pacific Marine Finfish Aquaculture Network and its activities. This is a 3.5 year project and the activities will covers Australia, Indonesia, Philippines, Thailand and Vietnam.

The overall objective of the project is to enhance the sustainability of marine finfish aquaculture in the Asia-Pacific region by improving hatchery production technology and facilitating the uptake of compounded feeds for grow-out. Progress and development of the project will be reported and made available to wider audience through the network website and newsletter. A brief project summary is given below.

Marine finfish aquaculture is an important contributor to the economies of coastal communities throughout the Asia-Pacific region. Although production of hatchery-reared fingerlings is increasing, much of the seedstock supply for this sector continues to be dependent on capture of wild fry and fingerlings, which limits fingerling availability and contributes to over-harvesting. Grow-out operations use 'trash' fish, which results in localised pollution and competes with other needs for fishery products. The previous project *Improved hatchery and grow-out technology for marine finfish aquaculture in the Asia-Pacific region* made substantial improvements to the sustainability of marine finfish aquaculture in the Asia-Pacific region. This follow-on project will continue lines of research that demonstrated maximum benefits in the earlier project, and will continue to support the synergies that were developed between partner agencies in the earlier project through collaborative research activities.

The follow-on project will focus on improving survival of hatchery-reared high-value marine finfish larvae, and increasing the reliability of hatchery production. Larval rearing technologies will be expanded to other high-value species such as coral trout (*Plectropomus* spp.). The grow-out diet development component of the project will focus on promoting uptake of compounded pellet diets at the expense of 'trash' fish use. Research activities will focus on identifying ingredients likely to lower diet cost and reduce environmental impacts (nutrient outputs).

A third component of the project will evaluate the socio-economic constraints to uptake of the technologies (hatchery production, artificial diets) and develop strategies to overcome these constraints. The communication and coordination strategies developed under FIS/97/73 will be continued and the Asia-Pacific Marine Finfish Aquaculture Network will be strengthened and expanded through a process of formalisation of participating agencies and individuals. Enhanced industry involvement in the network will be encouraged, and long-term network sustainability will be enhanced, by accessing corporate sponsorship of network activities.

These outputs will contribute to the development of sustainable marine finfish aquaculture in the Asia-Pacific region by increasing the supply of hatchery-reared fingerlings to support increasing demand for high-value marine finfish species for aquaculture. The use of compounded grow-out diets will reduce 'trash' fish utilisation and reduce pollution associated with the use of 'trash' fish as a feed source. The project will link closely with two other ACIAR projects: *Environmental impacts of cage aquaculture in Indonesia and Australia* (FIS/2003/027) and *Feasibility study of economic impacts of developments in the live reef fish food trade in the Asia-Pacific region* (ADP/2003/022).

NACA/DOF/TDH* Workshop on Seafarming and Seafood Markets

A one day workshop was held in NACA Secretariat Office at Bangkok, Thailand on March 25, 2004. The purpose of this workshop was to conduct a review of seafarming experiences and start to identify opportunities for future development in Thailand. The workshop was attended by some 50 participants.

The workshop aimed to assist the Department of Fisheries to prioritise future research and development activities in seafarming in Thailand, and provide opportunities for further cooperation with NACA, TDH and other stakeholders to strengthen research and development for seafarming in Thailand.

The workshop covered the following themes:

- Regional overview of mariculture
- Markets and demand trends for mariculture products
- Marine fish farming in Thailand
- Mollusc farming in Thailand
- Seaweed farming in Thailand
- Other seafarming species

The report of this workshop is available on the NACA website.

**TDH - Terre des Hommes Foundation-Italy. NACA has started cooperation with TDH project in Phanga Nga Bay, Southern Thailand entitled "Children of the Sea – Requalification of Small-scale Fisheries Micro-enterprises and Ecosystem-based Innovation of Aquatic Production Systems for the Sustainable Development of Thai Coastal Communities". The cooperation involves simultaneous studies of seafarming technology and markets in southern Thailand, Bangkok live fish markets and trading networks,* *regional markets and a status review of regional seafarming production technologies. Further information on the project will be made available through a new web site and a report expected to be available in July 2004. In the meantime, further information can be obtained from Paolo Montaldi or Sandro Montaldi at a.montaldi@tdhitaly.org.*

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