

Report of the APEC/NACA Cooperative Grouper Aquaculture Workshop



7-9 April 1999
Hat Yai, Thailand



Organised by the
Asia-Pacific Economic Cooperation (APEC)
in cooperation with the
Network of Aquaculture Centres in Asia-Pacific (NACA)



Collaborative APEC Grouper Research and Development Network (FWG 01/99)

**Report of the APEC/NACA Cooperative Grouper Aquaculture
Workshop**

**Hat Yai, Thailand.
7-9 April 1999**



Report prepared by:

Network of Aquaculture Centres in Asia-Pacific (NACA)

Suraswadi Building

Department of Fisheries

Kasetsart University Campus

Ladyao, Jatujak

Bangkok 10900

Thailand

Tel: +66 2 561 1728 (to 29)

Fax: +66 2 561 1727

E-mail: naca@enaca.org

Website: <http://www.enaca.org/>

For:

Copyright © 2002 APEC Secretariat

APEC Secretariat

438 Alexandra Road

#14-01/04 Alexandra Point

Singapore 119958

Tel: +65 276 1880

Fax: +65 276 1775

E-mail: info@mail.apecsec.org.sg

Website: <http://www.apecsec.org.sg>

Reference:

APEC/NACA. 2002. Report of the APEC/NACA Cooperative Grouper Aquaculture Workshop, Hat Yai, Thailand, 7-9 April 1999. Collaborative APEC Grouper Research and Development Network (FWG 01/99). Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. pp 140.

APEC Publication Number: APEC#202-FS-04.1

ISBN 981-04-6516-5

Contents

Introduction	1
Work Program	3
Workshop Outcomes	4
Annex I: Workshop Program	12
Annex II: List of Workshop Participants	15
Annex III: Opening Speech	21
Annex IV: Working Group Participants	23
Annex V: Grouper Papers	25
5.1 Status of Grouper Culture in Thailand	27
5.2 Hatchery Technology of Grouper in Thailand	37
5.3 Marketing and Exporting of Groupers in Thailand	45
5.4 Grouper Culture Development in Brunei Darussalam	53
5.5 The Status and Development of Grouper Culture in Guangdong	57
5.6 Development of a Regional Cooperative Network for Grouper Aquaculture Research	63
5.7 Grouper Aquaculture in the Philippines	75
5.8 Status and Development of Grouper Aquaculture in Pacific Island Countries	77
5.9 Cultured Grouper Diseases in Thailand	81
5.10 Fish Disease, Quarantine and Certification in Thailand	87
5.11 Natural Spawning and Larval Rearing of Barramundi Cod Grouper, <i>Cromileptes altivelis</i> in Tanks	91
5.12 Grouper Aquaculture in Korea	101
5.13 Recent Developments in Grouper Aquaculture in Hong Kong, China	103
5.14 Overview of Grouper Production Technology in the Asia-Pacific Region	107
5.15 Grouper Culture as a Tool in Marine Park Management – A Project of The Nature Conservancy, Indonesia Coastal and Marine Program	113
5.16 Nutritional Requirements of Grouper (<i>Epinephelus</i> spp.)	119
5.17 Grouper Aquaculture in Chinese Taipei	127
5.18 Surface-death Occurrence in the Larval Stage of <i>Epinephelus akaara</i>	131
5.19 Trends in Major Asian Markets for Live Grouper	133
5.20 Grouper Research at the Southeast Asian Fisheries Development Center Aquaculture Department	143

Workshop Proceedings

Introduction

This workshop represented the first of two to be hosted by APEC and NACA under the project 'Collaborative APEC-NACA Grouper Aquaculture Network' (APEC Project FWG 01/99). The workshop was held in order to further the development of a sustainable grouper aquaculture industry in the Asia-Pacific region through the establishment of a collaborative network of researchers.

The Workshop was attended by representatives from 12 APEC economies including Australia; Brunei-Darussalam; China; Chinese Taipei; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; Peru; Philippines and Thailand. The meeting was attended by representatives from NACA, the Secretariat for the Pacific Community (SPC), INFOFISH, New Caledonia and a non-governmental organisation, The Nature Conservancy (TNC). The objectives of the workshop were to establish a regional research network to:

- Facilitate development of a sustainable grouper aquaculture industry
- Reduce the reliance on wild fingerlings for coastal grouper aquaculture
- Contribute to the protection of endangered reefs and reef fish from illegal fishing
- Facilitate development of new aquaculture industries with significant export potential
- Provide an alternative source of income and employment to people currently engaged in destructive and illegal fishing practices.

The meeting was very successful with a number of recommendations made in support of APEC Fisheries Working Group (FWG) and NACA objectives for grouper aquaculture. Specifically, the Workshop recommended expansion of the cooperative development model applied during this workshop to other tropical marine fish projects, which it was felt, could form the basis for future cooperation between regional agencies.

Delegates from India, the Solomon Islands, and Vietnam were unable to attend this workshop but are interested in the proceedings and indicated their willingness to participate in network activities and project development.

Opening Ceremony

The opening speech was given by Mr Hassanai Kongkeo, NACA Coordinator. He outlined the objectives and expected outcomes from the workshop. Speakers from the Department of Fisheries, Thailand expressed their support for their cooperative activity and wished the workshop success. The detailed technical program of the workshop is in **Annex I** and the list of Workshop participants is given in **Annex II**. The speeches made during the opening ceremony are given in **Annex III**. Working Group participants are listed in **Annex IV**.

Presentation of Reports

The participants presented an overview of grouper aquaculture in their respective economies. The papers are in **Annex V**. The following summarizes the general topics:

- Status of Grouper Culture in Thailand, Renu Yashiro, Vichai Vatanakul and Poonsin Panichsuke
- Hatchery Technology of Grouper in Thailand, Paiboon Bunliptanon and Janejit Kongkumnerd
- Marketing and Exporting of Grouper in Thailand, Pongpat Boochuwong and Amporn Lawapong
- Grouper Culture Development in Brunei Darussalam, Beato Pudadera (Jr.), Hajah Laila Haji Abd Hamid and Hajah Rosinah Haji Mohd Yusof
- The Status and Development of Grouper Culture in Guangdong, Liufu Yongzhong
- Development of a Regional Cooperative Network for Grouper Aquaculture Research, M.A. Rimmer, K.C. Williams, M.J. Phillips and H. Kongkeo
- Grouper Aquaculture in the Philippines, Westly R. Rosario
- Status and Development of Grouper Aquaculture in Pacific Island Countries, Pierre Labrosse
- Cultured Grouper Diseases in Thailand, Yaowanit Danayadol
- Fish Disease, Quarantine and Certification in Thailand, Somkiat Khanchanakhan
- Natural Spawning and Larval Rearing of Barramundi Cod Grouper, *Cromileptes altivelis* in Tanks, Ketut Sugama, Trijoko, Wardoyo, John H. Hutapea and Shigeru Kumagai
- Grouper Aquaculture in Korea, Lee Young-Don
- Recent Developments in Grouper Aquaculture in Hong Kong, Jim Chu
- Overview of Grouper Production Technology in the Asia-Pacific Region, Michael A. Rimmer
- Grouper Culture as a Tool in Marine Park Management: A Project of The Nature Conservancy, Indonesia Coastal and Marine Program, Peter J. Mous, Jos S. Pet and Rili Djohani
- Nutritional Requirements of Grouper *Epinephelus* spp., Mali Boonyaratpalin
- Grouper Aquaculture in Chinese Taipei, Huei Meei Su

- Surface-death Occurrence in the Larval Stage of *Epinephelus akaara*, Kosaku Yamaoka
- Trends in Major Asian Markets For Live Grouper, Sudari Pawiro
- Grouper Research at the Southeast Asian Fisheries Development Center
- Aquaculture Department, Clarissa L. Marte

Work Program

Following the technical presentations, participants formed three Working Groups (**Annex IV**), each to consider a specific area relevant to the growth of a sustainable grouper aquaculture industry. The general objectives for each working group were to:

1. Evaluate the the topic being considered
2. Identify responsibilities in the grouper network and make recommendations
3. Identify additional research, development, or information requirements, and
4. Develop specific collaborative proposals to address the relevant issues

Working Group Topics

Working Group 1, ‘Production Technology: Research, Extension and Industry Development’. Specific objectives for this group were to:

- a) Develop a strategy for increasing collaboration between countries and institutions involved in grouper aquaculture research and development, and
- b) Develop an action plan to extend research and development outcomes to industry

It was recognised that Working Group One had the advantage of feedback from a previous ACIAR and NACA workshop. The need to evaluate the current status in relation to these issues was therefore not necessary. This working group therefore focused on collaboration and development of an action plan on grouper production technology.

Working Group 2, ‘Food Safety: Chemical Residues, Handling, Storage and Transportation; and Trade Issues: Certification, Labelling, Testing and Marketing’. Specific objectives for this group were to:

- a) Evaluate the current situation regarding food safety and marketing
- b) Develop strategies to overcome identified problems, such as safe use of chemicals, including training and extension, and
- c) Develop methodologies to address issues associated with trade compliance, labelling and testing

Working Group 3, ‘Social and Environmental Issues: Technology Transfer, Coastal Livelihoods, and Poverty Alleviation for Coastal Communities’. Specific objectives for this group were to:

- a) Evaluate the role of grouper aquaculture in coastal peoples livelihoods
- b) Evaluate the role for small-scale and medium-scale business in grouper aquaculture
- c) Identify environmental issues to be addressed in development of grouper aquaculture
- d) Develop methodologies for extending outcomes of grouper network activities to small-scale and medium-scale businesses in the Asia-Pacific region, and
- e) Develop an action plan for implementation

Workshop Outcomes

It was determined that a 5-year development program to support sustainable grouper aquaculture would be an effective means of integrating research, development, extension activities, and to promote cooperation between regional countries. This development program should contain the prioritised activities outlined below.

It was suggested that a cooperative development model be applied to other economically important marine fish species and a strategic assessment of opportunities for further development of marine fish farming in the Asia-Pacific region be undertaken. The focus of this assessment should be on opportunities for small and medium-scale livelihood and business development. This assessment should be based on a comprehensive market analysis.

Summary of Findings

There were overlapping issues and all three groups proposed, in one form or another, the need to develop and promote good management practices in grouper aquaculture. The groups indicated an immediate need to provide basic information to farmers and wild collectors of grouper, on disease management, farm management, transport, handling and use of chemicals in farming. In the medium to long term, guidelines will be required which may form the basis for development of a Code of Practice or other management guidelines for grouper aquaculture, and, more generally, for marine finfish culture in the Asia-Pacific region.

The Workshop agreed that while certification and labelling may prevent trade in wild grouper species caught using cyanide, the best way to prevent trade in these species was to promote trade in cultured product. This could be achieved through education

and marketing campaigns aimed at the consumer promoting cultured grouper and other reef fish.

The workshop supported the network approach to further research and development and considered that the existing network established by NACA (with ACIAR) was an effective platform on which to build.

Program Development Framework

The overall R&D model proposed to assist the development of sustainable grouper culture in the Asia-Pacific region is the Program model, in which a number of individual projects comprise an integrated program of activities. The individual institutes participating in the network would also be responsible for specific projects within their area of expertise. A R&D Program also provides an opportunity to link non-APEC activities and projects:

- Research projects undertaken by institutions and agencies involved in the network
- The FAO-NACA-OIE Regional Program on Health Certification and Quarantine for Responsible Transboundary Movement of Live Aquatic Animals which is supported through FAO, OIE, AusAID and other agencies, and
- ACIAR Project FIS/97/73, 'Improved Hatchery and Grow-out Technology for Grouper Aquaculture in the Asia-Pacific Region'

Specific technical projects developed by the Working Groups are listed below.

Technical Projects

Virus Transmission and Vaccine Development

The project objectives are to:

1. Investigate modes of transmission
2. Develop preventative measures for viral diseases through
 - a) Biological methods: Probiotics, control of environmental conditions
 - b) Immunological methods: vaccination, immunostimulants
 - c) Management measures
3. Develop techniques for rapid identification of viral diseases in grouper

Methods to achieve these objectives might include:

1. Vaccine, immunostimulant, biological control
2. Use of diagnostic methods to determine modes of transmission

3. Correlation of disease occurrences with environmental conditions
4. ELISA, PCR, development of dedicated grouper culture cell lines

The project uses the network of the ‘APEC Collaborative Grouper R&D Project’ and will be developed and run through the network. The workshop also agreed that as the transboundary movement of pathogens through trade in live groupers is a concern, this project should link into the FAO-NACA-OIE Regional Program on Health Certification and Quarantine for the Responsible Transboundary Movement of Live Aquatic Animals.

Participating institutions:

The National Institute for Coastal Aquaculture (NICA) in Songkhla, Thailand was suggested as the lead institute for this project. Other participating institutes might include:

- Hiroshima University (HU), Japan
- Department of Fisheries, Malaysia (DOFM)
- National Taiwan University (NTU) Chinese Taipei
- Queensland Department of Primary Industries (QDPI)
- Aquatic Animal Health Research Institute (AAHRI), Thailand
- Gondol Research Station for Coastal Fisheries (GRSCF), Bali, Indonesia, and
- South-East Asian Fisheries Development Centre Aquaculture Department (SEAFDEC AQD), Iloilo, the Philippines

Within this collaborative structure, components could be undertaken by organisations:

- Mode of transmission: NICA, GRSCF
- Biological control, probiotics: NICA, GRSCF
- Rapid diagnosis techniques: NICA, AAHRI, HU, NTU, and
- Immunological techniques: SEAFDEC AQD, GRSCF, DOFM, QDPI

Outcomes might include:

- Reduced reliance on antibiotics by developing vaccines
- Improved survival of aquacultured groupers through disease control, and
- Management protocols for responsible movement of groupers and control of diseases

Larviculture Research and Development

It is recognised there is already a high level of regional R&D directed at grouper aquaculture, particularly on larviculture. However, there is some degree of overlap and, in

some cases, outright duplication of effort. With this in mind, the priority for facilitating the development of improved grouper larviculture is staff exchanges to promote collaboration and coordination in the Asia-Pacific region.

A number of potential staff exchanges were identified at the workshop. An application procedure needs to be developed to assess the large number of applications that are expected. Applicants should develop proposals for specific research activities, so both parties know what activities are to be undertaken during the exchange.

Although the present Collaborative APEC Grouper R&D Network project allows four staff exchanges per year, there is a greater demand. Because successful larviculture is the primary bottleneck in the development of sustainable grouper aquaculture technology, it is proposed to increase the number of exchanges available through expansion of the existing project and through more effective use of technical cooperation among developing countries (TCDC).

Egg Quality Assessment

The workshop identified the need to develop methodology for assessing egg quality as an indicator of fish larval and seed quality. Some options for assessing egg quality include:

- Position and number of oil droplets
- Use pattern of initial egg cell divisions

Participating institutions:

The participating institutes for this project are:

- SINTEF Fisheries and Aquaculture, Norway
- National Institute for Coastal Aquaculture, Songkhla, Thailand
- Taiwan Fisheries Research Institute, Tungkang, Chinese Taipei, and
- South-East Asian Fisheries Development Centre, Aquaculture Department, Iloilo, the Philippines.

This project will be undertaken by the participating agencies using existing resources and facilities and will not require additional funding. However, access to staff exchanges funded under the Collaborative APEC Grouper R&D Network project would be useful in facilitating information exchange.

Development and Extension Projects

Training and Extension Program for Aquaculture

The workshop emphasised the importance of training and extension programs for sustainable grouper aquaculture. It was suggested that a training and extension program be implemented in three stages.

1. Development of a grouper health management manual for farmers in grouper production which builds on surveys undertaken through existing APEC projects
2. Development of an education and extension training program for farmers in regional areas. Methods to implement this would include ACIAR project meetings, APEC workshops within APEC-NACA projects and other regional training programs
3. Best practices for grouper aquaculture based on information provided by points 1 and 2 above, and other related regional projects

The immediate need identified by participants in the working groups was for the production of a manual which would collate existing information on grouper handling, disease prophylaxis and treatment, and related topics. Some of the available information identified by Working Group 1 included:

- Survey of disease of fishes in cage culture, Thailand
- Manual for pond culture of marine finfish, Chinese Taipei, and
- Manual of diseases of *Cromileptes altivelis*, Gondol RSCF

Topics to be covered in the manual would include:

- Fish handling
- Transportation
- Polyculture systems
- Cage maintenance and cleaning
- Prophylaxis prior to stocking in cages
- Early detection of fish health problems
- Water quality guidelines and site selection
- Storage and use of trash fish and pellet feeds
- Treatment regimes for specific fish health problems, and
- Wild seed; handling and transport, health monitoring, treatment, weaning and feeding

Participating institutions:

- Department of Fisheries, Malaysia

- Department of Fisheries, Guangdong, China
- National Institute for Coastal Aquaculture, Songkhla, Thailand
- Taiwan Fisheries Research Institute, Tungkang, Chinese Taipei
- Gondol Research Station for Coastal Fisheries, Gondol, Bali, Indonesia, and
- Queensland Department of Primary Industries, Fisheries Group, Australia

Information collation and preparation of the manual would be undertaken by the lead agency (SEAFDEC AQD). Participating institutions would be responsible to supply information, translation to their local language, and distribution of the manual through their existing extension networks.

Trade Facilitation Projects

Certification and Labelling Protocol to Prevent Cyanide Use

The workshop held a long discussion on the use of certification to identify and promote groupers from aquaculture and wild fisheries not using cyanide. It was suggested that a feasibility study be undertaken to assess the potential to apply the Philippine model for cyanide detection into a regional programme of trade certification. This would provide a framework to develop a credible live reef fish certification system and promote the aquaculture of groupers as the best means of achieving a broad range of conservation objectives. The project was suggested as a joint one between the APEC Fisheries Working Group (FWG) and the Marine Resources Conservation Working Group.

Environmental Projects

Environmental Impact Studies and Management Systems for Grouper Cage Culture

The workshop suggested environmental impact studies be carried out and management systems be developed for marine cage culture. It was suggested that such a project be carried out in several phases.

1. Collate existing information on management and environmental impacts of cage culture. Working Group 1 identified existing, readily available information from:
 - Chinese Taipei
 - RSCF Gondol (information on cage culture impacts)
 - Hong Kong, China (environmental evaluations of cage culture)
 - NICA, Thailand (collection of soil and water samples from cage culture areas), and
 - The World Aquaculture Society's Annual Conference [held in Sydney April 1999] (alleviating cage culture impacts)

2. Prepare monitoring protocols for consistent assessment techniques to be developed
3. Develop guidelines for environmental assessment and management of cage culture farming systems using the following tools and data sets:
 - Assess physiological tolerances of grouper (temp, DO ammonia, pH)
 - Determine optimum and limiting water quality factors for grouper culture, and
 - Develop a model for assessing carrying capacity of cage culture and pond culture.

The project was proposed as a joint project between FWG and the MRCWG.

Project Leader and Lead Agency

It was suggested that the NACA Secretariat initiate the development of the project in cooperation with concerned institutes within the region.

Asia-Pacific Development Strategy for Marine Fish Culture

The socio-economic group had wide ranging discussions on the role of grouper aquaculture in the development of coastal livelihoods and small and medium-scale businesses. The working group emphasised the following:

- Networking in grouper aquaculture should be extended to other species
- Aquacultures' potential to reduce illegal fishing would probably depend on offering appropriate incentives to coastal farmers and fishers
- There were a number of other marine fish species (including non-carnivorous species) which offered development potential
- Many coastal farmers involved in grouper aquaculture also farmed other species, and switched species depending on market conditions, and
- There are a number of coastal livelihood and environmental rehabilitation projects in the region. These projects should be integrated into the network

The group recommended a broader assessment of marine fish culture in the Asia-Pacific region, incorporating marketing, technical, economic, environmental and social issues as a basis for a medium term strategy for marine fish farming.

The project should build on the successful experiences of the grouper network to assess the potential for marine fish farming in the Asia-Pacific region and develop a regional cooperative strategy to meet development opportunities. Specific activities would include:

- Conduct marketing and product diversification analysis
- Prepare development scenarios for cultured fish species
- Conduct fish species analysis to determine development potential
- Identify opportunities for cooperative networking to further development and overcome constraints, and
- Undertake case studies to assist in the development of strategies and policies for marine fish culture and business development, including case studies on coastal livelihood and environmental rehabilitation projects (Komodo Island in Indonesia and coastal projects in Phuket, Thailand)

Project Development and Assessment

To further develop network activities and assess progress, the workshop suggested:

1. An annual review of progress and the development and adaptation of workplans in response to development needs
2. A revised workplan and budget for the APEC project based on the recommendations of the first workshop with:
 - More emphasis on information exchange
 - More emphasis on collaborative research, and
 - More emphasis on training and TCDC exchanges

Workshop Closing Remarks

The representatives from Australia (Paula Shoulder) and NACA (Dr Michael Phillips) thanked the participants for their active participation in the workshop and looked forward to future cooperation in the development of the network.

Annex I: Workshop Program

APEC-NACA-NICA Workshop on Grouper Research and Development, 7 - 9 April 1999, J.B. Hotel, Hat Yai, Thailand

Wednesday, 7 April

08.30h Registration

09.00h Official Opening Session

- Welcoming remarks – Mr Songchai Sahavacharin, Director, NICA
- Welcoming speech – Mr Hassanai Kongkeo, NACA Coordinator
- Opening remarks - Dr Maitree Duangsawasdi, APEC Fisheries Working Group member for Thailand
- Opening speech – Ms Paula Shoulder, on behalf of the APEC Fisheries Working Group Lead Shepherd
- Keynote address by Dr Sitdhi Boonyaratpalin, Deputy Director General, Department of Fisheries, Thailand

09.30h Coffee break

09.45h Introduction, objectives and expected outputs from the workshop

- NACA Developments to Date and a Potential Framework for Grouper Aquaculture Development in the Asian Region – Dr Michael Phillips
- APEC Interests and Perspectives – Ms Paula Shoulder, Australia
- ACIAR Interests and Perspectives – Mr Barney Smith, ACIAR

10.30h Status of grouper aquaculture research in APEC economies followed by discussion sessions (15 minute presentation followed by 5 minute discussion).

- Status of Grouper Culture in Thailand - Dr Renu Yashiro
- Hatchery Technology of Grouper in Thailand - Mr Paiboon Boonliptanon
- Marketing and Exporting of Grouper in Thailand - Mr Pongpat Boonchuwong
- Nutritional Requirements of Grouper *Epinephelus sp.* - Dr Mali Boonyaratpalin
- Grouper Aquaculture in Malaysia – Dr Hussin Bin Mat Ali

12.30h Lunch break

14.00h Status reports and discussion (continued)

- Grouper Aquaculture in the Philippines – Mr Westley R. Rosario
- The Status and Development of Grouper Culture in Guangdong - Mr Liufu Yongzhong
- Recent Progress in Grouper Aquaculture in Indonesia – Dr Ketut Sugama

15.30h Coffee break

15.45h Status reports and discussion (continued)

- Recent Developments in Grouper Aquaculture in Hong Kong - Dr J. Chu

- Grouper Aquaculture in the Indian Ocean and Bay of Bengal Region – Dr Sampson Manickam, India (paper submitted but not presented)
- Grouper Aquaculture in Chinese Taipei - Dr Huei Meei Su
- Grouper Aquaculture in Korea – Dr Young-don Lee
- Status and Development of Grouper Aquaculture in Pacific Island Countries – Mr P. Labrosse, Secretariat for the Pacific Community (SPC)

17.30h End of the session

Thursday, 8 April

08.30h Special review sessions

- Cultured Grouper Diseases in Thailand - Ms Yaowanit Donyadol
- Surface-death Occurrence in the Larval Stage of *Epinephelus akaara* - Prof. Yamaoka
- Quarantine and Certification of Groupers in Thailand - Dr Somkiat Khanchanakhan, AAHRI, Thailand
- Ongoing Initiatives Under the FAO-NACA-OIE Regional Programme on Quarantine and Health Certification for the Responsible Movement of Live Aquatic Animals – Dr Michael Phillips, NACA
- Marketing, Trade and Food Safety Issues – Mr Sudari Pawiro, INFOFISH
- Note on a Market Transformation Initiative – Dr Yvonne Sadovy, Hong Kong, China
- Grouper Culture as a Tool in Marine Park Management – A Project of The Nature Conservancy, Indonesia Coastal and Marine Program – Dr Peter J. Mous, TNC

10.30h Coffee break

10.45h Technical reviews

- Overview of Grouper Production Technology – Dr Mike Rimmer, Australia
- Progress in Grouper Larviculture Research at SEAFDEC AQD – Dr Clarissa Marte, SEAFDEC AQD, Philippines

11.45h Development of the network - working group sessions

- Working Group 1 Production technology: research and industry development
- Working Group 2 Food Safety: Chemical residues, handling, storage, transportation, Trade Issues: Certification, labelling testing, marketing
- Working Group 3 Social and environmental aspects, including technology transfer, coastal livelihoods/poverty alleviation for coastal communities

13.00h Lunch break

14.00h Afternoon field trip

- Visit to National Institute for Coastal Aquaculture (NICA)
- Dinner near seabass cage farm on Songkhla Lake

Friday, 9 April

09.00h Working group discussions (continued)

10.30h Coffee break

10.45h Presentations of findings by Working Groups followed by discussion

12.30h Lunch break

14.00h Finalisation/adoption of Grouper Network implementation plan and follow up recommendations

15.30h Coffee break

16.00h Closing Remarks

16.30h End of workshop [participants leave for home]

Annex II: List of Workshop Participants

BRUNEI DARUSSALAM

Mrs Hajah Rosinah Haji Mohd Yusof
Assistant Fisheries Officer
Fisheries Department
Ministry of Industry and Primary Resources
Jalan Menteri Besar, BB 3910
BRUNEI DARUSSALAM
Tel No: 383412 / 770706
Fax No: 382069
E-mail: ikanb11@brunet.bn

CHINA

Mr Liufu Yongzhong
Deputy Chief Guangdong Dayawan Fisheries
Development Center
Department of Marine and Aquatic
Products Guangdong Province, CHINA
Tel No: +86-752 557 7234
Fax No: +86-752 557 8672
E-mail: hzgdfdc@pub.huizhou.qd.cn

HONG KONG, CHINA

Dr Yvonne Sadovy
Department of Ecology and Biodiversity
The University of Hong Kong
Pokfulam Road
HONG KONG, China
Tel No: +85-2 2859 8977
Fax No: +85-2 2517 7997
E-mail: yjsadovy@hkusua.hku.hk

Dr Jim Chu
Aquaculture Fisheries Division
Agriculture and Fisheries Department
13/F Canton Road, Kowloon
HONG KONG, China
Tel No: +85-2 2733 2376/2873 8337
Fax No: +85-2 2314 2866
E-mail: jimmychu@chevalier.net

INDONESIA

Dr Ketut Sugama
Head, Gondol Research Station for Coastal
Fisheries
PO Box 140, Singaraja 81101, Bali
INDONESIA
Tel No: +62 362 92278
Fax No: +62 362 92272
E-mail: sugama@singaraja.wasantara.net.id

MALAYSIA

Mr Hussin Bin Mat Ali
Head, Marine Finfish Production and Re-
search Centre
Department of Fisheries
Tanjung Demong, 22200 Besut
Terrengganu
MALAYSIA
Tel No: +60 9 6956778
Fax No: +60 96958628
E-mail: pppil@po.jaring.my

PERU

Mr Victor Yepez
Peruvian Marine Institute
Acting Director of Aquaculture
Gamarra-General Valle s/n, Chucuito
P.O. Box 22 Callao
Tel No: +511 4297630
Fax No: +511 466 6023
E-mail: vyepez@imarpe.gob.pe

PHILIPPINES

Dr Clarissa Marte
Director, Research Division
SEAFDEC AQD
PO Box 2565000, Iloilo City
PHILIPPINES
Tel No: +63 33 335-1009/336-2965
Fax No: +63 33 335-1008
E-mail: clmarte@aqd.seafdec.or

Mr Westly Rosario
Center Chief, Bureau of Fisheries and Aquatic
Resources
National Integrated Fisheries Technology
Development Center
Dagupan
PHILIPPINES
E-mail: bfarwest@pang.pworld.net.ph

REPUBLIC OF KOREA

Dr Young-don Lee
Marine Research Institute
Cheju National University
#3288 Hamduk-ri, Chochon-eup, Buk-gun
Cheju-do 695-810
REPUBLIC of KOREA
Tel No: (82 64) 82-8922
Fax No: (82 64) 783 6066
E-mail: leemri@cheju.cheju.ac.kr

Dr Jong Pyo Seo
Director, Cheju Halla Fisheries
405-1, Buk-chon ri, Chochon-eup
Buk-gun Cheju do 695 810
REPUBLIC of KOREA
Tel No: (82-64) 783 8850
Fax No: (82-64) 783 9994

Dr Chi-Hong Kim
National Fisheries R&D Institute
408-1, Shirang, Kijang
Pusan 619-900
REPUBLIC OF KOREA
Tel No: (82-683) 582 8225
E-mail: puan0641@ppp.kornet21.net

CHINESE TAIPEI

Dr Huei Meei Su
Tungkang Marine Laboratory
Taiwan Fisheries Research Institute
Tungkang, Pingtung, 928. R.O.C.
TAIWAN
Tel No: (886-8) 832 4121 (283)
Fax No: (886-8) 832 0234
E-mail: suhm@ma.ks.edu.tw

JAPAN

Prof. Kosaku Yamaoka
Director, Usa Marine Biological Institute
Kochi University, Usa, Tosa, Kochi 781-1164
JAPAN
Tel No: +81 888-56-0633
Fax No: +81 888-56-0425
E-mail: yamaoka@cc.kochi-u.ac.jp

AQUATIC ANIMAL HEALTH RESEARCH INSTITUTE

Dr Somkiat Khanchanakhan
Fisheries Biologist
Aquatic Animal Health Research Institute
Kasetsart University Campus
Jatujak, Bangkok 10900
THAILAND
Tel No: (66 2) 5794122, 5796977, 5796803
Fax No: 66 2 561 3993
E-mail: somkiatkc@fisheries.go.th

AUSTRALIAN CENTRE FOR INTERNATIONAL AGRICULTURAL RESEARCH (ACIAR)

Mr Barney Smith
Research Program Manager (Fisheries)
ACIAR Fisheries Program Office
NSW Fisheries Research Institute
PO Box 21, Cronulla NSW 2230
AUSTRALIA
Tel No: +61 02 9527 8463
Fax No: +61 02 9523 5966
E-mail: smithb@fisheries.nsw.gov.au

BAYER

Mr Guo Fuci
Project Manager, Aquaculture-Asia
Bayer Thai
130/1 North Sathon Road, Bangkok 10500
THAILAND
Tel No: 66 2 2327219
Fax No: 66 2 2672804
E-mail: FUCI.GUO.FG@bayer-ag.de

EC/DOF ADANG PILOT PROJECT

Mr Paolo Montaldi
Senior Fisheries Expert
EC/DOF Adang Pilot Project
Andaman Sea Fisheries Development Center
77 Sakdidet Rd. Phuket 83000
THAILAND
Tel No: +66 76 391435
Fax No: +66 76 391139
E-mail: montaldi@phket.loxinfo.colth

OFFICE OF ENVIRONMENTAL POLICY & PLANNING

Mr Ramate Sukpum
A/g Chief, Marine and Coastal Resources
Sub-division
Office of Environmental Policy and Planning
60/1 Soi Phibun Wattana 7
Rama VI Road, Bangkok 10400
THAILAND
Tel No: +66-2-279 5202
Fax No: +66-2-279 8088

FONDEPES - PERU

Mr Ivan Soto Cardenas
Aquaculture Program Coordinator
FONDEPES
c/o, Asian Institute of Technology
P.O. Box 924, Khlong Luang
Bangkok 12120, THAILAND
Tel No: +66-2-524 7477
Fax No: +66-2-524 6200
E-mail: ASA87362@ait.ac.th

INFOFISH

Mr Sudari Pawiro
Trade Promotion Officer, INFOFISH
1st Floor Wisma PKNS
Jln Raja Laut, Kuala Lumpur
MALAYSIA
Tel No: +603 291 4466
Fax No: +603 291 6804
E-mail: infish@po.jaring.my

SECRETARIAT OF THE PACIFIC COMMUNITY

Mr Pierre Labrosse
Reef Fisheries Management Adviser
Secretariat of the Pacific Community
B.P. D5-98848 Noumea Cedex
NEW CALEDONIA
Tel No: +687 26 01 48
Fax No: +687 26 38 18
E-mail: PierreL@spc.org.nc

SINTEF

Mr Niels Svennevig
Head of Department of International Projects
SINTEF Fisheries and Aquaculture,
Trondheim
Norway
Tel No: +45-57 640 363
Fax No: +45-74 640 408
E-mail: niels.svennevig@post3.tele.dk

Mr Peter Lauesen
Hatchery Advisor
SINTEF Fisheries and Aquaculture
Trondheim
Norway
Tel/Fax: (45-74) 617 258
E-mail: pelaue@post.tele.dk

THE NATURE CONSERVANCY

Mr Peter J. Mous
Field Coordinator, TNC Indonesia
Coastal and Marine Program
Komodo Field Office, Kampung Ujung,
Labuan Bajo, Flores Barat
INDONESIA
Tel No: +62-385 41214
Fax No: +62-385 41224
E-mail: pmous@tnc.org

**DEPARTMENT OF FISHERIES,
THAILAND**

Dr Mali Boonyaratpalin
Senior Fish Nutrition Specialist
Department of Fisheries
Kasetsart University Campus
Jatujak, Bangkok 10900
THAILAND
Tel No: +66-2 940 6207
Fax No: +66-2 562-0517
E-mail: malib@fisheries.go.th

Mr Nipon Siripan
Director, Coastal Aquaculture Division
Department of Fisheries
Kasetsart University Campus
Ladyao, Jatujak, Bangkok 10900
THAILAND
Tel No: +66-2 561 4759
Fax No: +66-2 561 4759

Mr Pongpat Boonchuwong
Senior Economist, Fisheries Economic
Division
Department of Fisheries
Kasetsart University Campus
Ladyao, Jatujak, Bangkok 10900
THAILAND
Tel No: +66-2 562 0581
Fax No: +66-2 562 0580
E-mail: pongpatb@fisheries.go.th

Mrs Amporn Laowapong
Economist, Fisheries Economic Division
Department of Fisheries
Kasetsart University Campus
Ladyao, Jatujak, Bangkok 10900
THAILAND
Tel No: +66-2 562 0581
Fax No: +66-2 562 0580
E-mail: ampornl@fisheries.go.th

Mr Pojana Boonyanaat
Head, Marine Aquatic Aquarium
Phuket Marine Biological Center
THAILAND

Mr Supot Jungyampint
Head, Trang Coastal Aquaculture Station
Department of Fisheries
200 Mai Fard Sikao, Trang 92150
THAILAND
Tel No: +66-75 212177
Fax No: +66-75 212177

Mr Twee Chindamaikul
Director, Phang-nga Coastal Aquaculture and
Development Center
Department of Fisheries
164 Taimaung, Phangnga
THAILAND
Tel No: +66-76 432 212-4
Fax No: +66-76 432 213

Mr Kanit Chaiyakam
Director, Satun Coastal Aquaculture and
Development Center
Department of Fisheries, Satun
THAILAND
Tel No: +66-74 781 347
Fax No: +66-74 781 347

Mr Paiboon Bunlipatanon
Head, Krabi Coastal Aquaculture Station
Department of Fisheries
141 Saithai, Krabi
THAILAND
Tel No: +66-75 612 981
Fax No: +66-75 612 981

Mr Kowit Kaeoian
Fisheries Biologist
Phang-nga Aquaculture Station
Department of Fisheries
Phangnga
THAILAND
Tel No: +66-76 432 212 to 4
Fax No: +66-76 4432 213

Mr Wira Chareonpak
Fisheries Biologist
Nakhon Sri Thammarat Coastal Aquaculture
Station
Department of Fisheries
THAILAND

Mr Vira Jaroenpak
Department of Fisheries
3 Moo 3 Sichon District
Nakhon Sri Thammarat
THAILAND

Tel No: +66-75 536 157
Fax No: +66-75 536 157

Mr Montri Buabal
Prachuab Khiri Khan Aquaculture Dev.
Center
Klong-wan Muang
THAILAND

APEC FWG/AUSTRALIA

Dr Mike Rimmer
Principal Fisheries Biologist
Queensland Department of Primary Industries
PO Box 5396
Cairns, Queensland 4870
AUSTRALIA
Tel No: +61 07 4035 0109
Fax No: +61 07 4035 1401
E-mail: mike.rimmer@dpi.qld.gov.au

Ms Paula Shoulder
Director of Aquaculture
Fisheries and Aquaculture Branch
Department of Agriculture, Fisheries &
Forestry-Australia
GPO Box 858
CANBERRA ACT 2601
AUSTRALIA
Tel No: +61 2 6272 3847
Fax No: +61 2 6272 4215
E-mail: paula.shoulder@affa.gov.au

NETWORK OF AQUACULTURE CENTRES IN ASIA-PACIFIC (NACA)

PO Box 1040
Kasetsart Post Office
Jatujak, Bangkok 10903
THAILAND
Tel No: +662 5611728-9
Fax No: +662 5611727
E-mail: naca@enaca.org
grouper@enaca.org

Mr Hassanai Kongkeo
Coordinator
Email: hassanai.kongkeo@enaca.org

Dr Michael Phillips
Environment Specialist
E-mail: michael.phillips@enaca.org

Mr Yuan Yongming
Database Specialist
E-mail: yuany@fisheries.go.th

Ms Wiratee Udumlarp
Secretary
E-mail: wiratee.udumlarp@enaca.org

Ms Em-orn Rungreungwudhikrai
Project Technical Officer
Danish/SE Asian TCE-Project
E-mail: tcep@lox1.loxinfo.co.th

NATIONAL INSTITUTE OF COASTAL AQUACULTURE

Kaosan Soi 1
Songkhla 90000
THAILAND
Tel No: 66-74 311 895/312 076
Fax No: 66-74 442 054
E-mail: nicas@t-rex.hatyai.inet.co.th

Mr Songchai Sahawatcharin
Director

Ms Yaowanit Danayadol
Head, Fish Pathology Section

Mr Poonsin Panichsuke
Head, Coastal Aquaculture Biological Section

Mr Youngyut Predalumpaburt
Head, Coastal Environment Section

Mrs Tida Petchmanee
Head, Fish Nutrition Section

Mr Pairoj Sirimontaporn
Head, Resource Section

Dr Renu H Yashiro
Fisheries Biologist

Mr Vichai Vatanakul
Fisheries Biologist

Ms Janejit Kongkumnerd
Fisheries Biologist

Ms Sataporn Direkbusarakom
Fisheries Biologist

Mr Sunit Rojanapittayakul
Fisheries Biologist

Annex III: Opening Speech

Opening Speech by Mr Hassanai Kongkeo, NACA Co-ordinator

Dr Sitdhi, representatives from APEC, Dr Maitree and Paula Shoulder, Dr Songchai, colleagues, ladies and gentlemen. I am happy to welcome you, on behalf of NACA, to this Workshop on Grouper Research and Development, which is an important one for NACA under its second 5-year work programme. The government members of NACA – now covering 14 countries of the region - have requested increased emphasis be given to marine fish aquaculture, and strongly endorsed a regional project on grouper aquaculture during the last Governing Council meeting. I am pleased that we have such a good group of experts with us for the next three days, and am sure this meeting will lead to further important research and development work on this priority regional topic.

I would like to take this opportunity to express NACA's gratitude to APEC for co-sponsoring this workshop and the Department of Fisheries of the Royal Thai Government – and particularly the National Institute for Coastal Aquaculture (NICA) - for hosting this meeting here in Hat Yai. I particularly thank the Director of NICA, Dr Songchai; and Dr Renu, for their personal attention to the arrangements for this workshop.

I would also like to express my appreciation to the other agencies who have supported this workshop – particularly the Australian Department of Agriculture, Forestry and Fisheries, and also to ACIAR for their continued strong support to this regional programme.

In preparing for this workshop, we have all been impressed by the keen regional interest shown in grouper aquaculture – this shows the commitment and interest from governments, researchers and the private sector in the programme. We certainly look forward to a continuation of this strong support and participation from you, your institutes and governments, as we move into the further expansion of collaborative activities. I personally believe the support and interest by APEC, ACIAR, and other agencies and government institutions to cooperate in this workshop demonstrates a keen interest in the subject matter and willingness to cooperate to solve common regional research and development problems.

The subject of this workshop and broad participation – not only from aquaculturists, but experts in marketing and trade, fish disease, coastal fisheries and coastal community development - makes this a particularly interesting meeting, and also an important one in the NACA work programme. Grouper aquaculture makes a small but important contribution to coastal aquaculture production in several countries in East and South-east Asia. It also has an important role in helping to provide an alternative source of

high value fish to wild caught groupers, which are showing increasing signs of being heavily overfished, in some places using environmentally destructive fishing practices.

NACA has been involved in two previous workshops to try and promote cooperation in grouper aquaculture. The first in Sabah in 1996 showed that the region is still some way from the development of sustainable grouper aquaculture operations. An important finding of the workshop was also that many research groups are working on grouper breeding and larval rearing - but many are also repeating much of the same type of work and facing many similar constraints. This led to a further meeting in 1998 – with the strong support of ACIAR – which more clearly defined some of the key constraints and led to the development of a more comprehensive programme of research cooperation aiming to overcome some of the constraints in grouper breeding and grow-out. It is our hope that this cooperation with APEC will lead to further expansion of the cooperation in grouper aquaculture, including broader issues related to the markets and trade, sustainability and extension of findings to farmers and businesses. I believe that genuine cooperation among groups with common interest in this subject can do a lot towards overcoming the various constraints and lead to a sustainable development of grouper and coral reef associated aquaculture in coastal areas. I also firmly believe the type of cooperation being promoted through this cooperative networking approach can and should be more broadly applied in promoting marine aquaculture in the region. Indeed, it may be a model of such cooperation.

This grouper aquaculture cooperation is relevant in several ways to the NACA regional work programme. It is relevant to our efforts to promote sustainable marine aquaculture technologies for the region; it is highly relevant to the recent emphasis in the NACA Program on Sustainable Aquaculture for Rural Development particularly aquaculture that can contribute to alleviation of poverty among coastal communities; it will help generate ideas for the NACA-FAO Conference on Aquaculture in the New Millennium which will be hosted in Thailand during February 2000; and it is very relevant to NACA's ongoing core programme of human resources development for aquaculture in the Asian region. I am pleased to inform you that human resources development, through the promotion of cooperation in aquaculture education and training, will be the subject of a further cooperation with APEC over the next year. I am sure the present workshop will generate ideas which can be taken up in this new cooperative programme.

As we have a busy three days ahead of us, I shall now end by reiterating my thanks to our cooperating agencies and our words of warm welcome, on my behalf and that of the NACA Secretariat staff. Thank you, good morning and best wishes for a successful meeting and an enjoyable stay here in southern Thailand.

Annex IV: Working Group Participants

	Working Group 1	Working Group 2	Working Group 3
Chair	Clarissa Marte	Yvonne Sadovy	Maitree Duangsawasdi
Co-chair	Hassanai Kongkeo	Sudari Pawiro	Westley Rosario
Rapporteur	Mike Rimmer	Paula Shoulder	Michael Phillips
	Chi-Hong Kim	Boniface Jintony	Alessandro Montaldi
	Guo Fu Ci	Hajah Laila Binit Haji Abd Hamid	Barney Smith
	Huei-Meei Su	Hajah Rosinah Haji Hohd Yusof	Em-orn Rungreungwudhikrai
	Hussin bin Mat Ali	Jim Chu	Jim Enright
	Ivan Soto Cardenas	Kanit Chaiyakam	Kanjana Teawsee
	Janejit Kongkumnerd	Kosaku Yamaoka	Michelle Lam
	Ketut Sugama	Monton Eiamsa-ard	Nipon Siripan
	Kowit Kaeian	Pongpat Boonchuwong	Paolo Montaldi
	Liufu Yongzhong	Sitdhi Boonyaratpalin	Peter Mous
	Mali Boonyaratpalin	Somkiat Khanchanakhan	Pierre Labrosse
	P.E. Sampson Manickam	Sunit Rojanapittayakul	Pojana Boonyanaat
	Paiboon Bunliptanon	Tida Petchmanee	Ramate Sukpum
	Pairoj Sirimontaporn	Umporn Laowapong	Sataporn Direkbusarakom
	Poonsin Panichsuke	Yaowanit Danayadol	Supoj Jungyampint
	Renu Yashiro		Twee Chindamaikul
	Songchai Sahawatcharin		Vichai Vatanakul
	Supon Tansuwan		Youngyut Predalumpaburt
	Tanan Tattanon		
	Vichean Sakares		
	Wira Chareonpak		
	Yongming Yuan		
	Young-Don Lee		

Annex V: Grouper Papers

5.1 Status of Grouper Culture in Thailand

Renu Yashiro, Vichai Vatanakul and Poonsin Panichsuke

National Institute of Coastal Aquaculture

Department of Fisheries, Kaosan Soi 1, Songkhla 90000, Thailand

Abstract

Grouper (Epinephelus malabaricus and E. coioides) culture is reviewed and discussed with details from 1996 and 1998 workshops. Rearing of juvenile fish to market size is reported and discussed along with constraints of grouper culturing technology in Thailand. Recommendations and conclusions on required research are provided.

Introduction

Several species of groupers, snappers and seabass (*Epinephelus* spp. *Plectropomus* spp. *Cromileptes* sp. *Lutjanus* spp. and *Lates calcarifer*) are cultured in Thailand. Juveniles are mainly supplied from the wild. Only seabass (*Lates calcarifer*) seeds are available from government and private hatcheries. Mass propagation of grouper seeds, *Epinephelus malabaricus* or *E. coioides* has been performed by National Institute of Coastal Aquaculture (NICA) from 1990 to 1996, however, the production has been inconsistent. Though seeds of grouper *Epinephelus* spp. were produced (Julawitayanukul, et al. 1987, Sakares and Kumpang, 1988, Hunsopa, et al. 1990, Kungvankij, et al. 1986, Ruangpanit, et al. 1988, Doi, et al. 1991) the seed supply was not sufficient. Culture techniques for grouper in Thailand include earthen pond culture and cage culture. This paper presents the status of the culturing methodology including the nursing of juveniles, problems and constraints of culturing methods and research needed to solve these problems.

Grouper Culture Area

Thailand has over 40 species of groupers. All of them live in 12 to 30 ppt salinity and 22°C to 28°C. Groupers are cultured both in cages and ponds. About 90% of the farmers culturing groupers use nylon net cages set in natural seawater. Grouper is cage-cultured along the coastal areas of the southern and eastern part of Thailand, Chumporn, Satun, Krabi, Phuket, Ranong, Trang, Phang-nga, Rayong, Nakhon Srithamarat, Narathiwat, Songkhla, Pattani, and Trad Provinces. The area covers three million square meters and includes 15,895 cages for fish culture of which 35.6% are grouper cages. Pond culture is developed in Samut Sakorn, Samut Songkram, Petchaburi, Nakhon-srithamarat, Songkhla, Satun, Chantaburi and Trad Provinces. In Suratthani, Pechaburi,

Chachuangsoa and Samut Sakorn, pond culture of *E. coioides*, *E. malabaricus* and *E. tauvina* is also conducted in brackish water.

The percentage of cages culturing grouper in Satun province reported by Satun Coastal Aquaculture Development Center (1997-1998) was 67.85%. It decreased by 20.35% from the 1996 survey conducted by Sanbuga (Table 1). The total number of fish cages in Songkhla Lake and adjacent area is 4,400, of which 90% are seabass (*Lates calcarifer*), 9% red tilapia or 'Platubtim' and 1% are grouper (Thompolkkrang and Predalumpaburt, 1999).

Table 1: Location and numbers of grouper cage culture in Thailand

Province	Area (m ²)	Total Cages	Grouper Cages	Grouper Cages %
Chumporn	3,600	147	79	53.74
Suratthanee	1,338,720	357	-	0
Nakorn-srithamarat	570,720	102	13	12.75
Patalung	206,416	520	-	0
Ranong	58,496	834	435	52.16
Phuket	14,848	600	503	83.83
Phang-nga	45,392	3,979	2,055	51.65
Krabi	55,360	542	270	49.82
Trang	27,488	559	475	84.97
Satun	263,456	1,970	1,734	88.02
Pattani	82,208	1,553	2	0.13
Naratiwat	13,520	1,392	64	4.60
Songkhla	594,672	1,220	<10	0.82
Chachuangsoa	-	2,000	-	0
Rayong	-	10	10	100
Chantaburi	-	50	-	-
Trad	-	60	5	8.33
Total	3,274,896	15,895	5,655	35.6

Grouper Fry and Fingerling Sources

Grouper fingerlings are usually sourced from sites within culture areas. One constraint of grouper aquaculture is insufficient seed supply from the hatchery. Generally, 1 cm to 2 cm fry and 1 to 2 inch fingerlings are preferred for nursing with 3 to 5 inch preferred for stocking and culturing in cages.

Most grouper fry are trapped in the wild. The traps are made of dried twigs called 'yan li pow' and held together with nylon net. The traps act as shelter for the groupers. They are placed in mangrove canals and other coastal water (brackish water) areas and checked every two or three hours, sometimes less frequently. The traps are lifted, fish collected by scoop net and transported to a broker.

Some fishers use small mesh (0.5 cm to 1 cm) gill nets to block the waterway and collect the fry by lifting the net. Some use the push net to capture grouper fry. The fry may die because of stress caused by careless handling during harvesting and transportation.

Most of fingerlings are obtained following nursing of the wild captured fry but they are also trapped in the wild.

Juveniles are captured in a small trap called 'sai' or 'lob'. The traps are placed every evening in mangrove canals or reef areas and marked by floating flags. The traps are usually checked the following morning. Gill nets and large traps are used for catching grouper juveniles in some areas.

Nursing Fingerlings to Juveniles

Grouper fingerlings for *Epinephelus malabaricus* and *E. coioides* (1 cm to 2.5 cm) are sourced either from the wild or from a fish hatchery. They have to be nursed before culturing to market size. Concrete tanks, nylon net cages and ponds are used as nursing facilities.

Fingerlings are nursed in round or rectangular concrete tanks with a 30-ton capacity at a stocking density of 15-50 inds/m². They are fed minced fresh fish, wet, moist or dry pellets (Panbanpaew and Sakares, 1990) to satiation once or twice a day. Size grading is required to ensure uniformity and therefore minimize cannibalism.

Net cage (1x1x1.5 m³) nursing produces better results than nursing in concrete tanks. The growth and survival rates are superior at higher stocking densities. Fingerlings (5.7cm or 3.1 gm) fed on trash fish for seventy-five days at stocking densities of 300-500 inds/m² can reach juvenile stage (14.1 cm or 49.9 gm) with a survival rate of 91.1%. Environmental and water pollution in the area are the major causes of mortality.

Ponds with surface areas of 800 m² to 3,200 m² are used for nursing. Fingerlings are stocked at 25-100 inds/m² and fed with trash fish. They are partially or totally harvested by seine net and sold to culture. The survival rate of fingerlings in ponds is lower than those in concrete tanks and net cages.

In January 1998 and February 1999, the price of juvenile grouper, *Epinephelus malabaricus* and *E. coioides* was US\$ 0.225 (2 to 3 inch), US\$ 0.425 (4 to 5 inch), and US\$ 0.80 (6 to 7 inch).

Culture Systems for Grow-out

There are two culture systems for the grow-out of groupers, pond culture and cage culture.

Pond culture is practiced in Thailand. In brackish water areas, some shrimp farmers converted their ponds to fish culture; modifying their ponds to about two meters in depth. Fish pond construction and management (reviewed in Ruangpanit and Yashiro, 1994. DOF, 1993) recommended fish ponds be from 800 m² to 1,600 m² in area and approximately 1.5 m to 2.0 m in depth. The pond may be flooded two to three times and drained for cleaning during low tide by pump. The pond bottom is cleaned with lime (0.06 to 0.12kg/m²) for disinfecting and killing pests. The pond is filled during high tides and fertilized with chemical or organic fertilizers to ensure plankton bloom prior to releasing the juveniles into the pond. In the case of large fish (200 to 300gm), fertilizing the pond may not be necessary. During the culture period, 40% to 70% water exchange should be performed daily.

At least 30% of the total culture area should be used as a reservoir where water is held prior to pumping it into the culture pond. This can minimize the risk of environmental pollution, parasite and disease problems.

Groupers are usually cultured in cages at high density; few farmers grow grouper in ponds. Three farms at Samut Sakorn and one in Petchaburi had pond culture, all of them converted from shrimp farms because of serious problems in shrimp culture. One of these farms in Ban Leam District, Petchaburi Province, converted shrimp ponds for culturing grouper by excavating 50 cm. They used different sizes of ponds from 3,200 m² up to 12,800 m². Fingerlings of 2.5 cm (from NICA hatcheries in 1993) were nursed in fine mesh net fixed in the pond for one month, then released into the same pond by removing the net. They were partially harvested after 14 months. The 1.2 to 1.3 kg groupers were selected for export; FCR of 3.6:1 and a survival rate of 40% were achieved.

Live fish (1.0 to 1.2 kg) are exported to Malaysia, Singapore, Chinese Taipei and Hong Kong SAR at prices ranging from US\$ 2 to US\$ 69.2 per fish depending on species and season (US\$ 1 = 40 Baht). Details of the prices are presented in Table 2.

In 8,000 m² ponds stocked for ten months with locally bought 300 to 500 gm juveniles at a density of 1.5 inds/m², the survival rate was 75% with an FCR of 3.2:1 (June 1994, from Ruangpanit and Yashiro, 1994). Cage culture is very popular because of its convenience, higher production yield and lower initial costs compared to pond construction costs. The cage culture system can eliminate the problems of water management during the culture period. The cages are square or rectangular and vary in size: 1.5x1.5x2.5m³, 2x2x2.5m³, 3x3x2.5m³, 4x4x2.5m³, 5x5x2.5m³ and 10x10x3m³. The

mesh size depends on the size of fish to be cultured and ranges from 1 cm to 2.5 cm for nursery and from 5 cm to 7 cm for grow-out.

Fixed and floating cages are used for finfish culture. Selection of the cage type depends on the site location and availability of capital. The fixed cage is suitable for water less than 2.5 m in depth with a tidal range of 50 cm to 60 cm. This type is used in the eastern provinces (Rayong, Chantaburi, Trard) and some southern provinces (Chumporn, Surattani, Songkhla and Pattani). The floating cage is suitable in areas with water depth of more than two meters and the tidal range is greater than one meter. Rafts or floaters are made of wood and bamboo with styrofoam; steel bars are used for reinforcement. This type of cage is suitable for open sea locations in Satun, Trang, Krabi, Ranong and Phangnga.

Table 2: Prices of groupers, snappers and other marinefish

Species	Thai Common Name	1.0-1.2kg/pc Live/pc(US\$)	0.5-0.9kg/pc Live/kg(US\$)	Above 1 kg Dead/kg(US\$)
<i>Epinephelus malabaricus</i>	Pla Kao Dogg Dum	9.7 to 12.4	5.6 to 8.3	2.7 to 4.2
<i>E. cocoides</i>	Pla Kao Dogg Dang	4.4 to 9.7	4.1 to 8.3	2.7 to 4.2
<i>E. tauvina</i>	Pla Karang Parg-mae-	4.4 to 9.7	3.4 to 8.3	2.7 to 4.2
<i>E. lanceolatus</i>	Pla Kao Tang	19.4 to 34.6	13.9 to 27.7	2.3 to 5.6
<i>E. salmonoides</i>	Pla Kao Kae	4.1 to 6.8	3.4 to 6.3	2.7 to 4.2
<i>E. fuscoguttatus</i>	Pla Kao Suea	11.1 to 16.6	5.6 to 9.7	ND
<i>Lutjanus</i>	Pla Kapong Dang	3.4 to 5.8	ND	1.8 to 2.7
<i>L. johni</i>	Pla Kapong Tong	3.4 to 5.8	ND	1.8 to 2.7
<i>Plectopomus maculatus</i>	Pla Aunaruth or Kudsalad	13.9 to 16.3	ND	3.4- to .6
<i>Cromileptes altivelis</i>	Pla Karang Hong or Narngon	41.6 to 69.2	13.9 to 28.4	ND
<i>Cheilinus</i>	Pla Nok Kaew	41.6 to 69.2	ND	2.3 to 6.8
<i>Lates calcarifer</i>	Pla Krapong Khoaw	2.2 to 4.9	ND	2.0 to 3.4

Source: Yashiro, 1996

* Napoleon fish, Hump-headed Maori wrasse, Giant wrasse

US\$1 = 40 B April 1998

Stocking density for seabass cage culture can be as high as 300 fish/m² (Sakares, 1990) which is the same in Songkhla. However, the high stocking density with uneven fry sizes may cause about 50% mortality (Chua and Teng, 1982). The minimum size of juveniles for culturing in a grow-out cage should range from 7.5 cm to 10 cm. Sakares and Sukbunteang (1985) showed that there were no differences in growth and survival rates of seabass stocked at 24, 36 and 48 fish/m². An experiment during 1980-1983 showed densities of 100 fish/m² yielding 50 kg/m² over six months. Further experiments showed good results of culturing seabass in cages at very high densities. Densities of 150, 200, 250 and 300 fish/m³ at Rayong Brackishwater Fisheries Station allowed production of 83.2, 109.5, 125.3 and 148.7 kg/ m²/yr (Sakares, 1990).

Since 1980, the recommended stocking density in grouper cage culture has been 15 fish/m². However, fish are stocked at various densities from 30 to 200 fish/m² (Table 3). The optimum stocking density of grouper for cage culture in brackish water was shown to be a function of dissolved oxygen budget by Nabhitabhata et al. (1988). Lower optimum density was 58 fish/m³ or 75 fish/m² with possible stocking limit of 351 fish/m³ or 457 fish/m² for fish up to 500 gm, and 31 fish/m³ or 40 fish/m² for fish up to 1.2 kg with a possible limit of 187 fish/m³ or 244 fish/m². Sakares et al.(1990) showed no statistical differences in the growth, survival rate and fatness of fish cultured at the optimum stocking density (75 fish/m²) and high stocking densities of 100 and 125 fish/m² with addition of artificial shelters. However, the production rates were higher and FCR were lower at the high stocking densities. This result can be used as the basic culture model for increasing production in grouper cage culture. The culture site, soil substratum and water quality should be taken into account. Various stocking densities and production of grouper cage culture are shown in Table 4.

Table 3. Stocking densities and yield/m² of grouper in grow-out cages

Size (cm)	Size (mg)	Density (inds./m ²)	Average yield (kg/m ²)	References	Cage size
-	61.2 103.4 149.4	30 45 60	16.8 23.8 29.7 (6 months)	Sakares and Sukbuntaung, 1985	1x1x1.5 m ³
10-15	20 30 60	60 75 90	27.8 33.9 37.9	Sakares and Kumpang, 1987	1x1x1.5 m ³
16.2	83.7	75	31.8 (7 months)	Sakares and Kumpang, 1988	2x3x1.5 m ³
-	126.3	40 50 60	13.4 15.5 15.6 (5 months)	Julawitayanukul et al. 1987	1.5x3x1.5 m ³
12.3-16.9	62.8 to 67.1	75 100 125	31.6 44.5 53.7 (6 months)	Sakares et al. 1990	1x1x1.5 m ³

Table 4: Grouper cage culture at various stocking densities (6 months)

	Stocking Density (individuals/m ²)						
	30*	45*	60*	75**	90**	100***	125***
Final growth (g)	601.9	547.6	508.8	473.9	448.3	467.7	443.1
Survival rate (%)	93.3	97.0	96.7	95.5	93.7	95.7	96.8
Yield (kg/m²)	16.8	23.9	29.7	33.9	37.9	44.5	53.7
FCR : kg fish	8.82	-	-	6.33	6.78	5.2	4.8

* Sakares and Sukbuntaung, 1985, **Sakares and Kumpang, 1987a, *** Sakares et al. 1990

Maintenance of net cages is necessary as nets can be blocked by sediment, molluscs or seaweed. This can cause disease or parasite problems because of reduced water circulation. It is necessary to change, clean and dry netting materials every one to two months depending on accumulation. Rafts, sinkers and floats also have to be checked regularly. With high stocking densities, partial harvesting is recommended to eliminate the loss from cannibalism. Stocking fish at various times and rotation of the harvest is recommended to provide a continuous income stream. Water and sediment parameters from the grouper cage culture area in Satun province showed high accumulation of organic matter (nitrogen and phosphorus) after three to four years of operation (Songsangjinda et al. 1993).

The majority of fish farmers use trash fish for seabass and grouper feed. Trash fish include the yellowstripe trivially (*Selaroides leptolepis*), thread fin bream (*Nemipterus hexodon*), fringescale sardinella (*Sardinella fimbriata*), and round scad (*Decapterus russelli*). They are minced, chopped, cut or kept whole depending on the size of fish being fed. Trash fish is high in protein but lacks some vitamins, especially vitamin C. During the nursery period, trash fish are boned so feed may lack minerals. Sardines contain sufficient essential fatty acids, but other trash fish may not. When unfresh trash fish is used, some proteins are degraded and converted to histamine, ammonia and hydrogen sulfide. Some properties of fat are changed and many vitamins and minerals (vitamin C, A, B, D, E, Choline and Niacin) are lost or become less effective. This causes nutritional imbalance in fish and leads to lower resistance to diseases.

Problems, Constraints and Research Needed

Diseases are a serious problem for grouper culture. Bacterial and viral diseases cause high mortality in pond and cage culture. Research on prophylactic, chemical and self-immunization enhancements is important for disease prevention.

Nutritional studies of locally available feed (trash fish), and development of acceptable feed formula for grouper culture are required. This research may assist in improvement of the growth rate and shortening the culture period.

Environmental problems and pollution in the culture areas are the main causes of mass mortality. Research in environmental management and improvement of culture systems are recommended.

Poaching is one of the problems at culturing sites. It is linked to the areas economy.

Genetic improvement and development of a grouper breeding program are urgent issues. Research in these areas should be conducted as soon as possible.

References

- Chua T. E. and Teng, S. K. 1982.** Effect of food ration on growth, condition factor, food conversion efficiency and net yield of estuary grouper, *E. salmonoides* (Maxwell), cultured in floating net cages. *Aquaculture*, 27: 273-283.
- Department of Fisheries. 1993.** Manual for Brackishwater Fish Culture, Department of Fisheries, Ministry of Agriculture and Cooperative. 38 pp. (in Thai).
- Doi, M. M. bin Hj. Mohd Nawi, N. R. bin Nik Lah and Z. bin Talib 1991.** Artificial propagation of the grouper, *Epinephelus suillus* at the marine finfish hatchery in Tanjong Demong Terengganu, Malaysia. Department of Fisheries, Ministry of Agriculture, Malaysia. PP. 41.
- Hunsopa, Y. Jindamaikul, T. Sukaputh, S. Riewthong, W. and Duangsa, T. 1990.** Study on breeding and larval rearing of red spot grouper *Epinephelus tauvina* Phuket coastal development culture center. Technical paper No. 36, 24 pp.
- Julawitayanukul, P. Putinowarat, C. and Suteemechaikul, N. 1987.** Study on breeding of grouper, *Epinephelus tauvina*. Review of the research on grouper culture conference 23-25 February 1987 at NICA pp. 74-81.
- Kungvankij, P. Tiro, L. B. Pudadera B. P. and Potestas, I. O. 1986.** Induced spawning and larval rearing of grouper (*Epinephelus salmonoides* Maxwell) P. 663-666. *In*: Maclean, J. L. Dizon, L. B. and Hosillos, L. V. (eds). The first Asian Fisheries Forum. Asian Fisheries Society, Manila Philippines.
- Nabhitabhata, J. Prempiyawat, R. Klaokliang, K. and Kabinrum, S. 1988.** Estimation on optimum stocking density of grouper, *Epinephelus tauvina* (Forsk.) in cages on basis of dissolved oxygen budget: Pang-rat River. Rayong Brackishwater Fisheries Station Brackishwater Fisheries Division, Department of Fisheries. 27 pp.(in Thai with English Abstract).
- Panbanpaew, S. and Sakares, W. 1990.** Experiment on sea grouper, *Epinephelus malabaricus*, with dry pellet. Technical Paper No. 38/1990. Rayong Brackish water Fisheries Station Brackishwater Fisheries Division Department of Fisheries. 17 pp.
- Ruangpanit, N. and Yashiro, R. H. 1994.** A review of grouper, *Epinephelus* spp. and seabass, *Lates calcarifer* culture in Thailand. Paper presented in the workshop in Hawaii.
- Ruangpanit, N. Boonliptanon, P. Pechmanee, T. Arkayanont, P. and Vanakovat, J. 1988.** Propagation of grouper, *Epinephelus malabaricus* at National Institute of Coastal Aquaculture, Songkhla, Technical paper No.5/1988, National Institute of Coastal Aquaculture, Songkhla, Department of Fisheries, Thailand. 16 pp. (in Thai with English Abstract).
- Ruangpanit, N. Boonliptanon, P. and Kongkumnerd, J. 1993a.** Progress in the propagation and larval rearing of the grouper, *Epinephelus malabaricus*. p.32-42 *In*: The Proceeding of Grouper culture, Nov. 30 - Dec. 1, 1993. National Institute of Coastal Aquaculture, Songkhla, Thailand and Japan International Cooperation Agency, 133 pp.
- Sakares, W. 1990.** Experiment on Seabass, *Lates culcarifer* (Bloch), Cultured in Cages with Dry Pellet. Technical Paper No. 5/1990. Rayong Brackishwater Fisheries Station, Coastal Aquaculture Division, Department of Fisheries. 15 pp.(in Thai with English Abstract).

- Sakares, W, and Sukbunteang, S. 1985.** Experiment on grouper, *Epinephelus tauvina* (Forsk.) in Cage with Different Stocking Density. Technical Paper No. 1/1985. Rayong Brackishwater Fisheries Station, Brackishwater Fisheries Division, Department of Fisheries. 28 pp. (in Thai with English Abstract).
- Sakares, W. and Kumpang, P. 1987a.** Effect of Stocking Density on Growth and Production of estuary grouper, *Epinephelus tauvina* (Forsk.), Cultured in Cages. Technical Paper No. 3/1987. Rayong Brackishwater Fisheries Station Brackishwater Fisheries Division, Department of Fisheries. 24 pp. (in Thai with English Abstract).
- Sakares, W. and Kumpang, P. 1988.** Growth and Production of Brown Spotted Grouper, *Epinephelus tauvina* (Forsk.) Cultured in Cages. Rayong Brackishwater Fisheries Station Brackishwater Fisheries Division Department of Fisheries. 17 pp. (in Thai).
- Sakares, W. Sangpradab, S. and Soodmee, Y. 1990.** Experiment on Increasing Production of Brown Spotted Grouper, *Epinephelus tauvina* (Forsk.), by using Artificial Hides to Increase Stocking Density. Rayong Coastal Aquaculture Station, Coastal Aquaculture Division, Department of Fisheries. 24 pp. (in Thai with English Abstract).
- Sanbuga, T. 1996.** Area of Coastal Aquaculture in Southern Thailand during September 1994-September 1995. Extension paper 1/1996, National Institute of Coastal Aquaculture, 34 pp. (In Thai).
- Songsangjinda, P.; Na-anan, P. and Tanvilai, D. 1993.** Water and sediment quality in grouper cage culture area at Klong Pakbara, La ngu District, Satun Province. p. 112-119. *In: The Proceedings of Grouper culture*, Nov. 30 - Dec. 1, 1993. National Institute of Coastal Aquaculture, Songkhla, Thailand and Japan International Cooperation Agency, 133 pp.
- Thompokkrang, P. and Predalumpaburt, Y. 1999.** Coastal aquaculture areas and water quality survey in Songkhla Lake and coastal zone by using satellite image and geographic information system. Technical paper No 1/1999. National Institute of Coastal Aquaculture, 53 pp.
- Yashiro, R. 1996.** Status of grouper breeding and culture in Thailand. Paper presented at the Workshop on Aquaculture of Coral Fishes and Sustainable Reef Fisheries. Sabandar Bay Resort, Tuaran, Sabah, Malaysia 4-8 December 1996. 17 pp.

5.2 Hatchery Technology of Grouper in Thailand

Paiboon Bunliptanon¹ and Janejit Kongkumnerd²

¹*Krabi Coastal Aquaculture Station*

141 Moo 6, Sai-thai, Muang, Krabi 81000, Thailand.

²*National Institute of Coastal Aquaculture*

Kaosean Soi 1, Muang, Songkhla, 90000, Thailand

Abstract

*In 1999, grouper juveniles, *Epinephelus malabaricus* and *E. coioides* were produced at the Krabi Coastal Aquaculture Station and National Institute of Coastal Aquaculture. Natural spawning and larval rearing to juveniles was successful. The techniques and performances of mass rearing are described in this paper.*

Introduction

In Thailand, studies on breeding and larval rearing of grouper (*Epinephelus* sp.) were initiated in 1983 (Kangwankij et al. 1982) at Satun Fishery Station, Department of Fisheries. The success of spawning was based on implementation of an artificial breeding method together with hormonal inducement. Natural spawning was achieved in 1984 at the same Fishery Station. Studies on grouper breeding were conducted by many researchers such as Pakdee and Tandavanit (1985), Ruangpanit et al. (1986), Julavittayanukul et al. (1987), Rattanachot and Pakdee (1987), Sakares and Kumpang (1987), and Pechmanee et al. (1988), but these reported mainly on spawning success. An acceptable survival of viable larvae was not obtained. The larval survival rates varied in their studies but all reported very low percentages.

In 1993, reliable seed production techniques were developed. The Fisheries Biologist of National Institute of Coastal Aquaculture (NICA), Department of Fisheries, produced 123,193 grouper juveniles (Ruangpanit et al. 1993) and 340,000 juveniles in 1995 (Bunliptanon and Kongkumnerd 1995).

This paper discusses the success of natural spawning and larval rearing to fingerling stage of *E. malabaricus* at Krabi Coastal Aquaculture Station, Coastal Aquaculture Division, Department of Fisheries and *E. coioides* at NICA in 1999. Techniques, performance and the investigation of grouper spawning of two species, *E. malabaricus* and *E. coioides* will be addressed.

Broodstock Maintenance

In early 1998, ninety-five broodstocks having an average body weight of 8 to 12 kg, total length of about 65 cm to 73 cm and approximately five to eight years of age were transferred from Phuket Coastal Aquaculture Development Center, Satun Coastal Aquaculture Development Center and Trang Coastal Aquaculture Station. They were stocked in a 4,800 m² pond (1.5 m to 1.8 m depth). They were fed with fresh sardines or carangid fish once a day. The water was managed without aerating but seawater was added once a week. Broodstock were kept until September 1998. Subsequently, separation by species (*E. coioides* and *E. malabaricus*) and by sex was undertaken. They were stocked separately into 5'5'2 m³ net cages which were installed in the same pond. They were then fed 1% to 2% of their body weight once a day. To enhance masculine phenomenon, 1 mg of methyltestosterone was added to 1 kg of feed twice a week. To enhance gonadal development, commercial fatty acid booster (0.3 to 0.5 g/kg of feed) and vitamin E (400 mg/kg of feed) were embedded into the sardines and fed to broodstock once a week.

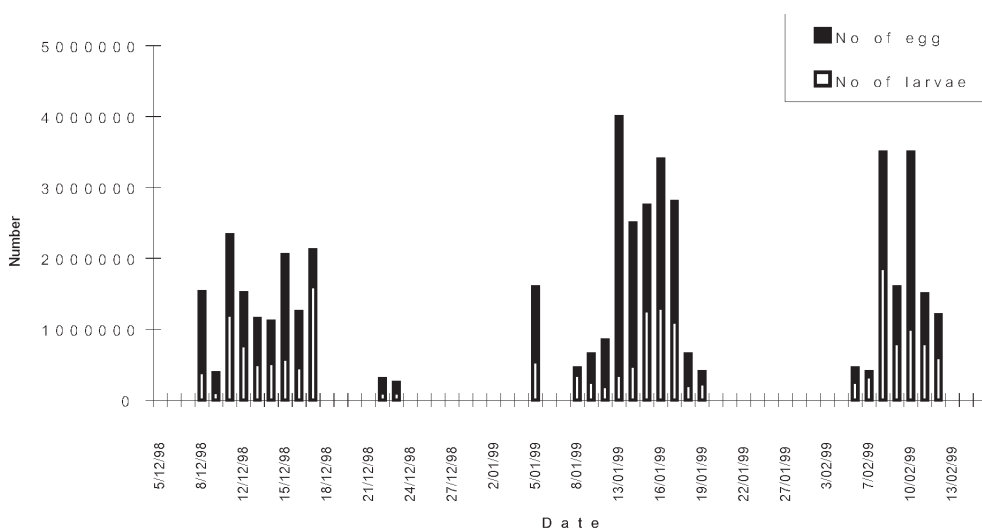


Figure 1. Number of grouper eggs and larvae at Krabi Coastal Aquaculture Station, 1998-1999.

Table 1: Number of eggs & larvae produced of grouper *E. coioides* in 1999 at NICA

Trial	Month	No. of eggs produced (x10 ⁶)	Average hatching rate (%)
1	Jan	8.0	1.38
2	Feb	21.2	35.2

At NICA, broodstocks were maintained in floating net cages after the spawning season. In September, about three months before spawning season, broodstocks were transferred to 150-ton, round concrete tanks. Twenty-six females ($8.5 + 2.3$ kg) and twelve males ($12.8 + 1.6$ kg) were cultured in separated tanks and fed in the same way as at the Krabi Coastal Aquaculture Station.

Spawning Study

In November 1998, at Krabi Coastal Aquaculture Station, both species of groupers (*E. coioides* and *E. malabaricus*) were transferred and stocked in rectangular spawning tanks (outdoor concrete tanks) with a capacity of 80 m³ and a depth of 1.8 m.

Spawning of *E. malabaricus* was stimulated and active from December 1998 to February 1999. The spawning activity occurred usually between 09:00 PM to 01.00 AM. This study did not assess whether all fish laid their eggs during the same period of spawning, however, the brood fish showed a typical lunar spawning rhythm. In this group, brood fish spawned naturally for a few days during the first study in November 1998. Their production was very low and spawned eggs were not fertilized. Only a few eggs produced on the first and second days of the spawning period. Highest production was attained at about the third to sixth day and then decreased as the spawning advanced. The second study performed in January 1999 and third study performed in February, were successful for both spawning and larval rearing. The number of eggs and newly hatched larvae in 1998-1999 is shown in Figure 1. Unfortunately, broodstock of *E. coioides* did not spawn in this study.

At NICA, natural spawning of *E. coioides* occurred in January, a month after being transferred to the same tank. The first batch of eggs was poor and had a very low fertilization rate. Eggs laid in the second batch were better. The number of eggs and newly hatched larvae in 1998-1999 is shown in Table 1.

Egg Collection and Incubation

The grouper laid their eggs between the full and new moon. Eggs floated on the surface of the water and had a diameter of about 800-900 μ m. The eggs should be observed every morning to detect spawning. In this study, eggs were collected using seine nets and transferred to an incubation room and put into 200-liter fiber glass tanks. The sinking eggs were separated. The floating eggs were brought for incubation and placed in 500-liter, round plastic tanks. Hatching set consisted of fine mesh nets hanging in 500-liter round plastic tank and provided with a continuous flow of seawater (3 to 4 liter/min), and moderate aeration. The stocking density was about 500,000 to 800,000 eggs per tank. Subsequently, the hatched larvae were collected using torch light and transferred to another rearing tank the next morning.

Larval Rearing

The trial for larval rearing was conducted in three phases and depended on the age and morphology of the larvae. Phase I (from day 1 to day 12-15), the larvae were raised at a stocking density of 40,000 to 70,000 larvae /ton. In Phase II (from day 12-15 to day 34-50), larvae were transferred to a new tank at a stocking density of 2,000 to 3,000 larvae/ton to improve survival rates. Phase III (from day 35-40 to fingerling stage), the larvae were stocked at a density of 1,000 to 1,500 larvae/ton.

Every phase was carried out in indoor hatchery tanks. Tank sizes used in trials varied. Krabi Coastal Aquaculture Station used 3, 10 and 12-ton round concrete tanks for larval rearing while 25-ton rectangular concrete tanks were used at NICA.

Figure 2: Feeding scheme for grouper juvenile rearing

Type of Feed	Days After Hatching											
	0	5	10	15	20	25	30	35	40	45	50	55
Rotifer	_____											
<i>Chlorella</i> sp.	_____											
Enriched <i>Artemia</i> nauplii	_____											
Enriched adult <i>Artemia</i>	_____											
Fish meat	_____											

Table 2: Juvenile grouper production Krabi Coastal Aquaculture Station, 1998-1999

Trial	No. Larvae (initial)	No. Larvae (day 12-15)	No. Larvae (juvenile)		Survival Rate (%)	Total Juvenile Production
			No.	TL		
1 (Dec)	6,329,000	-	-	-	-	-
2 (Jan)	4,890,000	610,000	60,000 85,000	2-3 cm 7-9 cm	2.96	145,000
3 (Feb)	2,440,000	114,000	35,000	2-3 cm	1.43	35,000

Table 3: Juvenile grouper production, *E. coioides* at NICA, 1998-1999

Trial	Date	No. Larvae (initial)	12 day larvae		Juvenile Production	
			No.	Survival Rate (%)	No.	Survival Rate (%)
1	Feb.18	500,000	102,00	20.40	14,000	2.8
2	Feb.19	740,000	100,00	13.51	61,600	8.32
3	Feb.20	700,000	93,000	13.29	65,000	9.40
4	Feb.21	800,000	147,00	18.38	59,000	7.44
Total		2,740,000	442,00	16.13	199,60	7.28

Feeding

Larvae were reared in seawater which was kept around 26°C to 29°C. The open-mouth size of larvae after the transition of endogenous to the exogenous stages was about 145 micron. The s-type rotifer was applied for the starter feeding. The larvae were fed rotifer from day 2 to day twenty-five after hatch-out. Screened small rotifer passing through a 125 µm net was used as starter feed for the first two to six days. The density of rotifer was maintained at about 10 to 15 individuals/ml. During this period, green algae water of *Chlorella* sp. was added daily and maintained at 0.2 to 0.3 × 10⁶ cells/ml to make up the transparency of the water and as food for the remaining rotifer. Enriched *Artemia* nauplii were subsequently introduced to the larvae from day fifteen to day forty, depending on larvae acceptance for those nauplii. The *Artemia* nauplii were enriched with a commercial fatty acid booster (Selco, 50 ppm, 8 - 12 hr) before being fed to the larvae. When the larvae grew up and the mouth opened wider, adult *Artemia* were enriched with the same fatty acid booster at a concentration of 50 ppm for three to six hours and applied to the larvae from the larval age of about day thirty-five. Fish meat was served to the larvae from day forty. The feeding scheme of larval rearing is shown in Figure 2.

Water Management

Filtered seawater was used for all developmental stages of grouper larval rearing. The salinity was 28 to 30 ppt for initial rearing. Just after hatch out, the newly hatched larvae were very sensitive. Aeration was maintained at about 0.1 to 0.2 l/min. Seawater in the rearing tanks was exchanged 10% to 25% from day seven. The bottom sediments were siphoned out twice a week from day seven to fifteen and more often when the juveniles were fed on adult *Artemia*.

Survival Rate

In this study, the survival rates of grouper *E. malabaricus* at Krabi Coastal Aquaculture Station from hatching to day 12 to 15 were 0% (December 1998), 12.47% (January 1999) and 4.67% (February 1999) for the 1st, 2nd and 3rd trials respectively. The total production of juvenile was 145,000 and 35,000 juveniles for the 2nd and 3rd trials, respectively. Consequently, the survival rates of larvae which reached the juvenile stage, were 2.16% and 1.43% for the 2nd and 3rd trials, respectively. The results of juvenile production are shown in Table 2.

The total juvenile production of larval rearing trials at NICA conducted in this spawning season (January 1999) was 199,600 juveniles after forty-five days of rearing. The survival rates ranged from 2.8% to 9.40% with an average of 7.28% (n=4). The results of juvenile production are shown in Table 3.

During larval rearing, the highest mortality occurred during the early stages, from hatching to day seven. Rearing tests rarely showed the survival rate in excess of 20% at this stage. This is similar to *E. akaara* fry, which at the age of seven days floated at the water surface and died (Maruyama et al. 1993). The high mortality may be due to the quality of eggs, nutrition deficiencies, intensive water movement in the tank, or swollen swim bladders from supersaturated water in the tank (Doi, 1991). Another high mortality period occurred when the larvae grew to thirty days. It might be due to the cannibalistic behavior of this species. To solve this problem, the larvae should be sorted by size as early as possible.

The sorting size of larvae is related to “shock” sensitivity of larvae from day 25 to day 35. Feeding of *Artemia* enriched with É-3HUFA during this period results in improved survival rate, as well as ensures faster growth and higher stress resistance (Runpanit et al. 1993, Watanabe et. al. 1983, Sorgeloose et al. 1987). Furthermore, feeding with cultured *Artemia* promotes its growth. In this study, sorting was conducted on day 38. The survival rate from day 14 to day 45 was 40% to 65%.

Rearing of grouper larvae requires intensive care, so it may be difficult to carry out stable mass production of grouper fry.

Suggestions and Perspectives

In Thailand, grouper is the one of the most popular marine finfish species. Its popularity stems from the high consumer demand and market situation. The seedling requirement for the intensive cultivation (net cages and pond cultures) is mainly met by larvae and juveniles gathered from nature. The collection of larvae and juveniles is seasonal and is limited by environmental pollution and over-fishing of adult and broodstock. Grouper hatchery in Thailand has been studied for over ten years, but the production of grouper larvae or juveniles still cannot ensure a year-round supply. The seed production at grouper hatcheries often yields more than 100,000 juveniles per crop, but it is still based on lots of grouper brood fish. Some grouper species are the androgenic hermaphrodite which reverse sex during their growing period, from female during the first cycle of growth to male in later cycles. The grouper breeders often experience shortage of male broodstock. To ensure a stable fertile seed supply, meet growing demand of the grouper fish farmers, and to cater to the needs of sea-ranching, broodstock management (control of maturity and control of qualities of brood fish and their eggs), and the improvement of larval techniques should receive more attention.

References

- Bunliptanon, P. and J. Kongkumnerd. 1995.** Mass seed production of grouper *Epinephelus malabaricus* in 1995. Proceedings of the Seminar on Fisheries 1995. Department of Fisheries. pp. 461.
- Doi, M. bin Hj. Mohd Nawi, N. R. bin Nik Lah and Z. bin Talib. 1991.** Artificial propagation of grouper, *Epinephelus suillus* at the marine finfish hatcheries in Tanjong Demong Terengganu, Malasia. Department of Fisheries, Ministry of Agriculture, Malaysia. pp.41.
- Julawitayanukul, P. 1987.** Effect of vitamin E on development of grouper eggs. In: Proceedings of the meeting on “ Reconsidering results of research on grouper propagation” at National Institute of Coastal Aquaculture, Songkhla. 23-25 February 1987. pp. 22-129.
- Julavittayanukul, P. C. Puthinawaratt and N. Suteemechaikul. 1987.** Study on grouper hatchery and nursery. In : Proceedings of meeting on “ Reconsidering results of research on grouper propagation” at National Institute of Coastal Aquaculture, Songkhla. 23-25 February 1987. pp. 74-81.
- Kangwankij, P. P. Chulavittayanukul, and N. Suteemechaikul. 1982.** Breeding of grouper *Epinephelus tauvina* by artificial insemination. In : Abstracts of the twentieth conference Fisheries Section. Kasetsart University, Bangkok, Thailand. February 1- 5, 1982. pp. 35.
- Maruyama K.K. Nogami, Y. Yoshida and K. Fukunaka. 1993.** Hatchery technology for the breeding and seed production of red spotted grouper *Epinephelus akaara* in Japan. Japan Sea-Farming Association, Goto Station, Tamanuora, Nagasaki. pp.02-05.
- Pakdee, K. and S. Tandavanit. 1985.** Breeding of brown spotted grouper *Epinephelus tauvina* at Phuket Brackish Water Fisheries Station. In: Proceedings of the 2nd Research Seminar of Fisheries Science Division, 1985, Kasetsart University. pp. 129-137.
- Pechmanee, T. M. Assavaaree, P. Bunliptanon, and P. Akkaynon. 1988.** Possibility of using rotifer, *Brachionus plicatilis* as food for early stage of grouper larvae, *Epinephelus malabaricus*. Technical paper No. 4/1988, National Institute of Coastal Aquaculture, Songkhla, Thailand. 10 pp.
- Rattanachot, A. and K. Pakdee. 1987.** Experiment on propagation and nursing of brown spotted grouper (*Epinephelus tauvina*). In Proceedings of meeting on Reconsidering results of search on grouper propagation at National Institute of Coastal Aquaculture, Songkhla, 23 –25 February. 1987. pp.93-109.
- Ruangpanit, N. P. Boonliptanon and J. Kongkumnerd. 1993.** Progress in propagation and larval rearing of grouper, *Epinephelus malabaricus*. In Grouper Culture, The Proceedings of grouper Culture. Viva Hotel, November 30-December 1, 1993, Songkhla, Thailand. pp. 32-44.
- Ruangpanit, N. P. Bunlipatanonl, T. Pechmanee, P. Arkayanont and J. Vanakovat. 1986.** Propagation of grouper. (*Epinephelus malabaricus*). In: Research seminar on grouper propagation. 30 Nov. to 1 Dec. 1993. At Viva Hotel, Songkhla. pp. 17.

- Sakares, V. and P. Kumpang. 1987.** Study on method of propagation and nursing of red spotted grouper, *Epinephelus tauvina* (Forsk.) at Rayong brackishwater fisheries station. In Proceedings of meeting on “Reconsidering results of research on grouper propagation” at Natonal Institute of Coastal Aquaculture, Songkhla, 23–25 February. 1987. pp. 110–121.
- Sorgeloose, P. Ph. Leger, P. Levens and W. Tackeart. 1987.** Increased yields of marine fish and shrimp production through application of innovative techniques with Artemia. Aquaculture and Development, Cahiers Ethologie Appliquee. 7: 43-50.
- Watanabe, T. C. Kitajima and S. Fujita. 1983.** Nutritional levels of live food and organisms used in Japan for mass propagation of fish : review. Aquaculture. 34 : 115-143.

5.3 Marketing and Exporting of Groupers in Thailand

Pongpat Boonchuwong and Amporn Lawapong

*Fisheries Economics Division, Department of Fisheries,
Bangkok 10900, Thailand*

Abstract

This paper describes the marketing and export of groupers in Thailand, which also provide information on traders and marketing channels that have been used in Thailand. It also covered the economic aspects of the cage culture of grouper in Thailand in various locations.

Introduction

Grouper culture in Thailand has existed for over 20 years. The two sources are from the wild (92%) and cultured groupers (8%). In 1996, total production of cultured groupers was 774 tonnes; cage cultured groupers constituted 93% and pond cultured groupers 7%. Groupers are cultured on the Andaman coast, the eastern coast and the western coast of the Gulf of Thailand. The production of cage culture from these areas (723 tons) account for 73%, 25.4% and 1.6% respectively (Table 1). During the last five years, production volume of cultured groupers varied due to shortage of fries and environmental problems such as the quality of water on the sea coast.

Economics of Grouper in Cage Culture

According to a survey of grouper cage farmers on the Andaman coast (1997-1998), the average size of a grouper farm was four cages. The farmers had from seven to fifteen years of experience. The fries were collected and released into cages from May to August (Table 2). The culture period was from two to nine months depending on the size of the fry. The average output was 210 kilograms per cage or 175 fishes per cage. The fish size was from 1 to 1.2 kilograms. The average cost was 31,245 baht per cage or 149 baht per kilogram or 179 baht per fish. Feed costs accounted for 57% of the total production costs, fry costs accounted for 24%, and capital, depreciation, maintenance and other costs accounted for 19% of total cost (Table 4).

Most farmers started to harvest in the ninth month and continued up to the twelfth month of the culturing period. The number of harvests was three to four. The average revenue was 61,251 baht per cage or 292 baht per kilogram or 350 baht per fish. The average net profit was 30,006 baht per cage or 143 baht per kilogram or 172 baht per

Table 1: Production of cage culture grouper in Thailand, 1992-1996

Province	1992		1993		1994		1995		1996	
	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%
East Coast (Gulf of Thailand)	88	9.6	182	27.3	168	27.6	228	37.0	184	25.4
Trat	-	-	25	3.8	44	7.2	99	16.1	86	11.9
Chanthaburi	85	9.3	137	20.6	108	17.7	107	17.4	73	10.1
Rayong	3	0.3	5	0.8	7	1.1	12	1.9	5	0.7
Other	-	-	15	2.3	9	1.5	10	1.6	20	2.8
West Coast (Gulf of Thailand)	41	4.5	10	1.5	16	2.6	35	5.7	11	1.6
Chumphon	25	2.7	3	0.5	5	0.8	4	0.6	4	0.6
Surat Thani	16	1.7	1	0.2	6	1.0	25	4.1	5	0.7
Others	-	-	6	0.9	5	0.8	6	1.0	2	0.3
Andaman Sea Coast	787	85.9	474	71.2	425	69.8	253	41.1	528	73.0
Ranong	127	13.9	136	20.4	147	24.1	63	10.2	179	24.8
Phang-nga	247	27.0	92	13.8	95	15.6	134	21.8	229	31.7
Phuket	13	1.4	29	4.4	7	1.1	4	0.6	8	1.1
Krabi	54	5.9	28	4.2	17	2.8	28	4.5	22	3.0
Trang	140	15.3	31	4.7	47	7.7	55	8.9	11	1.5
Satun	206	22.5	158	23.7	112	18.4	69	11.2	79	10.9
Total	916	100	666	100	609	100	616	100	723	100

Table 2: Period of grouper culture (Andaman Coast, 1997-1998)

Activities	1997									1998		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Seeding		←			→							
Feeding		←										→
Harvesting							←		*	*	*	→

Source: Survey, * High price

fish. The rate of return on investment was 96%, which was higher compared to that from other aquatic animal cultures (Table 5).

Marketing and Export of Cultured Grouper

Approximately 85% of cage cultured groupers are exported live. Many traders are involved because the output must be distributed quickly.

Table 3: Characteristics & production for grouper farms (Andaman Sea Coast 97-98)

Item	Number of Units
1. Characteristics:	
• Experience in grouper culture	7 to 5 years
• Number of cages	4 cages per farm
• Size of cage	4 x 4 x 4 meters
• Number of seed	250 fries per cage
• Seed price	30 baht per fry
• FCR	8.5 : 1
• Feed price	10 baht per kg.
2. Average Production:	
• Yield per farm	840 kg.
• Yield per cage	210 kg or 175 fish

Table 4: Production costs of grouper culture (Andaman Coast, 1997-98)

	Average Production Costs				
	Per farm (baht)	Per cage (baht)	Per fish (baht)	Per kg (baht)	%
Fixed Costs	18,378	4,595	26.3	21.9	14.7
• Depreciation	4,000	1,000	5.7	4.8	3.2
• Opportunity	14,378	3,595	20.5	17.1	11.5
Variable Costs	106,600	26,650	152.3	126.9	85.3
• Seed	30,000	7,500	42.9	35.7	24.0
• Feed	71,400	17,850	102.0	85.0	57.1
• Repair	2,000	500	2.9	2.4	1.6
• Other	3,200	800	4.6	3.8	2.6
Total	124,978	31,245	178.5	148.8	100.0

Source: Survey

Traders and Marketing Channels

The major agencies involved in the marketing system are brokers, collectors (wholesalers) and exporters. The marketing channel details are presented in Figure 1. The marketing process can be divided into local and exporting levels.

People involved at local levels are brokers and collectors. Most of them are the main grouper farmers in the area. Brokers and collectors have different roles. Brokers are responsible for monitoring the grouper prices, informing the farmers, contacting the collectors or wholesalers, charging broker's fees from the buyers and serving as a guarantor for payments made by buyers. Brokers charge buyers a fee of 5 to 10 baht per fish. The collectors are either from the area or from nearby areas. They are respon-

Table 5: Revenue and profit of grouper farms (Andaman Coast, 1997/1998)

	Revenue and Profit of Grouper Farms			
	Per farm (baht)	Per cage (baht)	Per fish (baht)	Per kg (baht)
Average revenue	245,003	61,251	350.0	291.7
Net profit	120,025	30,006	171.5	142.9
Rate of return (%) *	96.0			

Source: Survey; * Rate of Return = (net profit divided by total cost)

sible for collecting fish from small-scale farms. They collect until the minimum target number per trip is achieved. The number should be about 130 to 250 fish per trip to bring the transportation costs to an acceptable level. Every collector has regular customers. Payment is made on the day following the day of the purchase. The average marketing costs of collectors is 26.5 baht per kilogram or 31.8 baht per fish and the average net profit is 13 baht per kilogram (Table 6).

There are approximately 20 exporters of live groupers. Most are exporters of several kinds of live aquatic animals such as frogs, eels, prawns and soft-shell turtles. The major markets for export are China and Hong Kong SAR. Live groupers have been exported for more than fifteen years. Some exporters are agencies or networked with foreign importers, such as Hong Kong SAR and China. As a result of high demand in foreign markets, the grouper market is very competitive. Groupers are transported by plane. Live groupers are put in low temperature water with ice to lower their metabolic rate during transportation. Then they are packed into plastic bags with 5 to 6 fish per bag with one-third water and filled up with oxygen. The bags are packed into foam boxes with a gross weight of 12.5 to 13.0 kilograms. The average marketing costs for exporters is 100 baht per kilogram or 120 baht per fish and the average profit is 94.3 baht per kilogram (Table 6).

Profit Margin

The exporters profit margin is higher than that of the collectors, even though marketing costs for the exporters are higher. The exporters rate of return on investment is as high as 94.4%, whereas the collectors' rate of return is 49.2%. Exporters get a higher return because they have access to foreign market information.

Farmers get 55.5% of the price foreign importers have to pay. The rest (44.5%) is the trader's share, of which the exporters take 37% and collectors 7.5% (Table 7). Exporters bear higher risk than the collectors. The risk is potential death of fish during the export process. Exporters take this risk into account in calculating profit margins and if losses are lower than expected, the exporters earn a higher profit margin.

Table 6: Marketing costs & profits for live grouper collector and exporter (1997-98)

	Monthly Average (Baht)	0% Fish Death		3% Fish Death		5% Fish Death	
		per kg (Baht)	per fish (Baht)	per kg (Baht)	per fish (Baht)	per kg (Baht)	per fish (Baht)
Collector ¹							
Marketing costs	21,955	26.5	31.8	27.4	32.8	-	-
Profit	10,797	13.0	15.6	12.1	14.6	-	-
Rate of return	49.2						
Exporter ²							
Marketing costs	100,000	100.0	120.0	103.1	123.7	105.3	126.4
Profit	94,370	94.3	113.2	91.2	109.5	89.1	106.9
Rate of return	94.4						

Source: Survey

¹ Trade volume: 828 kg per month, or 690 fish per month

- Marketing costs: truck depreciation (16%), gasoline (20%), wages (18%), and others (46%)

² Trade volume: 1,000 kg per month, or 833 fish per month

- Marketing cost: transportation (66%), packaging (15%), wages (8%), and others (11%)

Table 7: Profit Margin of live grouper marketing system (1997-98)

Items	Baht per kg		Price Sharing (%)	
1.Export price (CIF)		525.6		100.0
2.Farm price		291.7		55.5
3.Marketing margin *		233.9		44.5
3.1 Collecting margin		39.6		7.5
• Marketing cost	26.5		5.0	
• Profit	13.0		2.5	
3.2 Exporting margin		194.3		37.0
• Marketing cost	100.0		19.1	
• Profit	94.3		17.9	

Source: Survey

Conclusion

Grouper culture generates higher profits than the culture of most other aquatic animals. Foreign market demand for groupers is highest from November to February, but grouper production does not increase during this period due to the shortage of fry. This constraint makes it difficult to plan for and produce grouper on demand.

Moreover, increasing feed prices and seasonal shortages, increase the culturers' costs. As loans from financial institutions are not available for grouper cage culture, most culturers use their own money or borrow from neighbours at high interest rates.

Periodic shortages of grouper production increase costs for exporters. Exporters have to gather groupers and keep them in storage ponds until the ordered number is col-

lected. Alternatively, exporters have to buy other aquatic animals in substitution for grouper to transport to foreign markets.

One solution is to improve hatchery techniques and switch to an artificial diet. Another way is to improve pond grouper culture techniques. Currently, unused prawn culture ponds are used for grouper culture. However, price of pond cultured grouper is lower than that of cage cultured grouper because lower flesh quality. If the culture technique is improved and the quality of fish meat is improved, pond grouper culture will become another way to increase grouper production.

References

Lawapong, A .1986. *Grouper Marketing in the South of Thailand.* Fishery Policy and Planning Division, Department of Fisheries. (in Thai).

Lawapong, A .1986. *Costs and Earnings of Grouper Cage Culture in Phangnga.* Fishery Policy and Planning Division, Department of Fisheries. (in Thai).

5.4 Grouper Culture Development in Brunei Darussalam

Beato Pudadera (Jr.), Hajah Laila Haji Abd Hamid and Hajah Rosinah Haji Mohd Yusof

*Fisheries Department, Ministry of Industry and Prime Resources
Jalan Menteri Besar, BB 3910, Brunei Darussalam*

Abstract

This paper covers the technical overview of grouper aquaculture in Brunei Darussalam which include culture techniques, disease and environmental issues. It also covers some markets and trades locally and as well as overseas. The key issues and constraints are briefly described and recommendations were suggested.

Background

Brunei Darussalam is drawn to grouper culturing because of high market prices and strong demand for grouper in export markets, particularly Hong Kong SAR. Grouper species such as *E. malabaricus*, *E. tauvina*, and *E. bleekeri*, are common in Brunei waters. Grouper fingerlings are caught using fish traps known locally as “bubu”. A survey on the quantity of grouper fingerlings in Brunei waters was conducted in 1993. The results of the survey indicated that grouper fingerlings were abundant in Brunei Bay. However, as the bay is surrounded by mangrove vegetation, trapping of grouper fingerlings is difficult. The grouper fingerlings are widely distributed in the area. In the coral areas, attempts were made to collect grouper fingerlings by the “bubu” trap but the results were not promising.

Groupers have been cultured in floating cages since 1990. Grouper fingerlings are stocked at the rate of 10 to 20 per m³. The size of most net cages is 4m x 4m x 3m. The survival rate of fingerlings during the first two months of culture is quite low (30% to 70%) mainly because of the stress from transportation, diseases and cannibalism. The growth rate is high; they are able to reach 500 g in five to six months.

The Department of Fisheries has been involved in Research and Development programs on breeding and seed production of grouper since 1990. Broodstock culture and conditioning were carried out in floating cages and the seed was produced in hatcheries. Induced breeding by hormones was tried and a modified larval rearing protocol from seabass larvae was used for the grouper larviculture. Breeding of grouper appears to be similar to seabass but the larviculture aspects still need a lot of fine-tuning.

Technical Overview of Grouper Aquaculture

Cage Culture

Grouper culture in floating cages was promoted by the Department of Fisheries because of the high demand and market prices at the export markets. A pilot cage culture project was started in 1993. The project dealt with the grouper fingerlings survey in Brunei waters and grouper production for export. Several types of fish traps were tried with the involvement of the local fishing communities. The results were not encouraging due to the limited number of grouper fingerlings caught by the traps. Therefore, the grouper cage culture project depended heavily on imported grouper fingerlings. Grouper fingerlings were imported from Philippines, Indonesia, Thailand and Malaysia. Prices were high and mortality was experienced within the first two months of culture. Fingerlings were susceptible to bacterial, fungal and parasitic infestation after they were stressed from transportation. However, good quality fingerlings or those that recovered from stress and disease tended to grow fast at 70 to 100 grams per month. Groupers in cages were fed with moist feed and trash fish.

At present, there are 18 floating cage farms with a total of 691 cages. The floating cages are mostly 4m x 4m x 3m. The total production of marine fish achieved in 1998 was 73 tonne, of which approximately 10% were groupers. Groupers are sold locally at restaurants and hotels. Cage culture technology for grouper is well developed in Brunei Darussalam.

Fish Disease and Quarantine Issues

Imported grouper fingerlings are examined for parasites and bacterial infection. The infected fish are treated with chemicals or temporarily held in tanks prior to stocking. Healthy or good quality fingerlings are stocked directly in nurseries or in cages. The transport water (water in PE bags) is treated with highly concentrated formalin before it is discharged. The newly stocked fingerlings are closely monitored by the Department of Fisheries. The purpose of monitoring is to provide assistance to farmers if further treatment is needed, either with chemicals or bath with freshwater

Environmental Issues

The Department of Fisheries has a plan for sustainable aquaculture in Brunei. It includes aquaculture zoning; allocating specific areas for particular aquaculture activities. The number of farms and farm sizes in these areas are determined by the Department of Fisheries. Three areas are identified for cage culture; the maximum carrying capacity is set at 80 cages per hectare. Water quality is regularly monitored with dredging and suctioning if necessary. A license is required to operate an aquaculture farm. Licensing

allows the Department of Fisheries to maintain strict control over the aquaculture activities in the areas.

Social and Economic Aspects

Cage culture of grouper is expected to boost export of fish. This will provide improvement to the profitability of cage culture operations and assist in raising incomes through fingerling collection.

Markets and Trade

The local market demand for grouper is low. Most of the local people believe that grouper is not good, especially for those with asthma. However, grouper is a preferred fish in Chinese markets where they are sold mainly in restaurants and hotels.

Groupers have been exported to Hong Kong SAR since 1994. For higher priced groupers, shipment by air appears to be economically viable. For species with lower prices, shipment by boat appears to be more cost-effective. These two modes of transporting live groupers to Hong Kong SAR are compared in Table 1. Live groupers transported by plane are sold at the auction market at an average price of US\$ 21.00 per kg.

Groupers transported by boat are purchased at farm price of US\$ 8.50 per kg, where the buyers come to pick-up fish at the farm. The gross profit per kilogram (after deducting the transportation cost) for the live groupers transported by air averages US\$ 8.7 per kilogram, for those picked-up at the farm it is about US\$ 7.8 per kilogram.

Several elements make for superior grouper marketing. Good connections and relationships with wholesale buyers are very important as is proper handling by sellers and buyers to ensure a high survival rate. Proper pre-transport conditioning facilities equipped with water temperature control, water filtration and re-circulating systems are needed to maintain high-quality live groupers.

Key Issues and Constraints

The main constraint in grouper culture is the supply of grouper fingerlings. Hatchery production of grouper fry is still at the research and development stage, therefore the supply of grouper fingerlings relies heavily on imports. Imported grouper fingerlings are expensive and the survival rate is low. Most of the imported grouper fingerlings are stressed, weak and susceptible to bacteria, fungal and parasitic infestation. It takes about two months for the full recovery of stressed fingerlings.

Recommendation

Given the constraints in the Brunei Darussalam grouper culture, a regional joint effort is required to refine and develop a reliable seed production technology. This effort would be of great importance in sustaining the development of the grouper culture industry.

It is believed that increased use of trash fish will cause environmental problems. Formulated feeds should be developed to minimise polluting effects.

Regular and up-to-date information on market prices and demand would be useful to producers as would improved logistics to reduce transportation costs and fish death during transportation. A close regional collaboration in standardisation of health certification, and disease monitoring of cultured and marketed groupers would be beneficial. This would provide some assurance that a proper analysis had been carried out. The HACCP for the shrimp could be adopted as the standard format or procedure.

Table 1: Comparative transport costs in marketing live groupers to Hong Kong

	By air	By boat
A. Expenditures		
• Air cargo, 6,644 @ US \$ 1.33/kg	US\$ 8,836.52	
• HKSAR handling cost, 6,644 kg @ HK 1.16/kg	988.08	
• Airport inspection charges, 26 boxes @ HK 3/box	102.30	
• Transportation charges/shipment @ HK 260	33.33	
• Sales handling charges/shipment @ HK 300	38.46	
• Export permit @ B\$ 20.00	13.33	US\$ 13.33
• Packaging, 266 boxes @ B \$ 2/box	354.66	
• PVC bags @ B\$ 6/box,	1,064.00	
• Oxygen, etc.	6.66	
• Overtime pay (for staff)	414.72	
• Shipping agency fee	-	916.56
• Commission (15%)	4,095.00	
Total	US\$ 15,947.06	US\$ 929.89
B. Sales		
• Sales of 1,300 kg black grouper 0.6 to 1.0 kilogram size @ US\$ 21/kg for by air and US\$ 8.50/kg for by boat.	US\$ 27,300.00	US\$ 11,050.00
C. Gross Profit	US\$ 11,352.94	US\$ 10,120.11

Assumption: 1 US\$ = 7.8 HK and 1 US\$ = 1.5 B\$

Based on 1.3 tonne shipment

5.5 The Status and Development of Grouper Culture in Guangdong

Liufu Yongzhong

Guangdong Dayabay Fishery Development Centre (GDFDC)
Huiyang City, Guangdong Province, P.R.China 516081

Abstract

The domestic production of groupers from capture fisheries is far from fulfilling the large market demand, therefore it is important to develop techniques for grouper culture. In China, Guangdong is the main consumer market for groupers and also the main producer. With 20 years of experience in grouper culture, it is now looking for a way to further develop its grouper culture industry.

Production and Consumption

The majority of groupers in the market (some 30 species) come from the wild. A significant portion of these groupers are imported from Southeast Asian countries and Australia. The main market for groupers in China is Guangdong where high value groupers are sold live. Guangdong Province has a permanent population of 70 million, and a transient population of 10 million. With the current economic growth, the market demand for grouper is enormous. The production of groupers from capture fisheries in China is far from fulfilling the large market demand. The shortage in supply is met by importing groupers from neighboring countries. The increasing demand will lead to over fishing for the grouper species, and will result in ecological imbalance. Therefore it is of utmost importance to develop techniques for grouper culture.

The Present Status of Grouper Culture

Grouper culture in China is concentrated in the four coastal provinces of Guangdong, Fujian, Zhejiang and Hainan. There are about 10 species of groupers currently being cultured in Guangdong. The yellow grouper (*Epinephelus awoara*) and brown-spotted grouper (*Epinephelus fario*) are the two most common species in culture. Polka dot grouper (*Cromileptes altivelis*), red grouper (*Epinephelus akaara*) and giant groupers (*Epinephelus lanceolatus*) command higher prices. In 1997, 110,000 net-cages for mariculture were operating in Guangdong (20,000 were used for grouper culture) producing 2,500 tons of grouper.

The main method of grouper culture in Guangdong is net cage culture in shallow water. Only a small portion are kept in ponds which also culture shrimp. Sixty percent of the

fry used in culture are from the wild, 20% are imported from Southeast Asian countries, and 20% are artificially produced fry imported from Chinese Taipei. Trash fishes are used for feed.

Grouper culture in Guangdong is carried out mainly by individuals in small-scale operations. Large-scale operations run by enterprises are not yet fully established in Guangdong. Groupers are collected and sold to fish transporters, who take them to wholesale fish markets or restaurants. There are no hygienic inspections or quality checks during this process.

Constraints

The culture techniques for grouper fry are still not well established, and culturists rely on wild capture and imported grouper fry. When demand for grouper fry exceeds supply; the result is higher prices and inconsistent quality. These factors affect the production volume of farms and increase the risk of operations. The supply of fry is a constraint in the further development of grouper culture.

During the culturing period, only trash fish is used as feed. Trash fish is increasingly scarce. Its supply and quality are affected by seasonal factors such as weather. Fish farmers tend to buy a large quantity of trash fish during the peak season while the price is low. This practise results in excessive feeding and water pollution. If trash fish is not stored properly, the quality deteriorates, which leads to slow growth. When the supply of trash fish decreases and the price rises, farmers tend to reduce feeding, which results in poor growth and diminished resistance to diseases.

The bottom sediment of Guangdong cage culture zones is beginning to age which might give rise to disease problems. The survival rate of cultured groupers in Guangdong is only from 40% to 50%. One of the reasons for the low survival rate is the lack of proper disease prevention.

The main method for live transportation of groupers in China requires large quantities of water. The cost of this transportation is high and the number of fish that can be transported is limited.

There is no quality assessment of groupers that are traded in the market in terms of food safety. No permit system is in place, therefore, the quality of cultured groupers is not checked.

Development of Artificial Reproduction Techniques

In the early 80s, research departments in Zhejiang, Fujian and Guangdong Provinces started to study artificial reproduction of yellow grouper and red grouper. Intensive

research was conducted but the tests were restricted to the laboratory. The funding was limited, and the number of broodstocks bought was small. The number of fertilized eggs was far from what was required for a large-scale production, so the amount of fry produced did not satisfy demand of grow-out farms.

In 1997, the Guangdong Dayabay Fisheries Development Center (GDFDC), in cooperation with the Overseas Fishery Cooperation Foundation (OFCF) of Japan, carried out research on the artificial reproduction of red grouper and yellow grouper. The natural spawning of red grouper succeeded in 1998. A small number of fingerlings of yellow groupers up to 5 cm was also successfully produced. At present, the GDFDC has 200 red grouper broodstocks aged from three to five years and 200 yellow groupers aged from three to seven years. The research on the fry production of these two species was continued in 1999.

The present technical problems of artificial reproduction of groupers include synchronizing spawning so that large amount of fertilized eggs can be collected at the same time. This would prevent predation at the fingerling stage and assist in developing the technology of large-scale production.

Further Development of Grouper Culture

Guangdong Province has a coastal line of 3,368 km with many sheltered bays. The potential for further development of fish culture is enormous. Based on the survey results, 40% of the 110,000 net cages for marine finfish culture in Guangdong produce groupers, but half of them cannot achieve target production due to shortage of fingerlings and financial constraints. Guangdong also has over 20,000 hectares of salt-water ponds, which were constructed during the “shrimp culture boom” 10 years ago. The outbreak of shrimp diseases rendered over half of these ponds unproductive. Reconstruction of these ponds to culture fast-growing high-valued fish (groupers), would provide better use of limited natural resources and create employment.

Summary

Guangdong Province has great potential and advantages for grouper culture. The following factors are important for a sound development of grouper culture in Guangdong.

1. It is important to develop simple efficient and effective grouper reproduction techniques, which would be practical for the farmers to adopt. In China, freshwater fish fry production has been a success, although it does not use a high level of technology or intensive systems. It is suggested that the method of extensive culture of freshwater fish fry should be used for grouper fry culture to maximize the fry production with minimum inputs.

2. Large scale fry production requires a large number of broodstock in order to produce a large amount of fertilized eggs. This cannot be achieved by ordinary fish farmers. Guangdong Province intends to offer government subsidies to encourage international cooperation and establish a grouper broodstock bank in GDFDC. The broodstock bank will act as a base for fry research and development and provide fertilized eggs or fry to fish farmers.
3. Guangdong Province has over 20 years experience in grouper cage culture. The number of the species and quantity of production are very significant. Therefore, it can serve as a source station for sexually matured broodstock for research and development purposes. Guangdong can also become a base station to provide research and development of grouper culture in the Southeast Asia region.
4. Besides the existing method of shallow water cage culture, there is a need to further develop cage culture in the outer-sea region, pond culture and indoor factory for grouper species.
5. Provide favorable policy to implement foreign techniques and attract foreign capital to Guangdong for the development of grouper culture.
6. Substitution of assorted trash fishes by artificial compound feeds could lower the dependence on capture fisheries, minimise pollution, and reduce the pressure on marine resources. The aquatic product techniques promotion network in Guangdong Province will fully support the introduction of grouper compound feed, as this will allow the transfer of advanced technology and techniques into Guangdong from overseas.
7. Development of common disease control techniques is important for improving the survival rate in grouper aquaculture. It is vital to establish a regional disease control research center of international and national nature, as this will allow collaboration of research resources from various institutions to develop practical techniques on prevention and control of diseases. This would provide strong support for grouper culture development in the region.
8. The establishment of a good network of after-sales service is an important tactic for the survival and sound development of the grouper fry industry. Good after sales service is carried out by most of the developed countries. Only a few developing countries can provide this service, which is of particular importance to fish farmers in these countries. Fish farmers in developing countries have lower technical standards and know how, and insufficient capital. Therefore it is important to sell them high quality fry at a low cost, provide technical support through extension training, and supply them with disease control instructions. This will help in improving and stabilizing production.
9. The establishment of sales permits, hygienic and quality inspection systems will ensure healthy fry for fish farmers, good products for consumers and assist in creating competitive advantage for the producers in the markets.

We hope that international cooperation and research on grouper artificial reproduction will enhance the development of marine fish culture and provide good protein source

for human consumption. The development of aquaculture could reduce the amount of wild caught fish and decrease pressure on marine resources. It is an important measure in maintaining marine ecological equilibrium and sustainability of limited resources.

5.6 Development of a Regional Cooperative Network for Grouper Aquaculture Research

M.A. Rimmer¹, K.C. Williams², M.J. Phillips³ and H. Kongkeo³

¹*Queensland Department of Primary Industries*

Northern Fisheries Centre, PO Box 5396, Cairns, Queensland 4870, Australia

²*Commonwealth Scientific and Industrial Research Organisation*

Division of Marine Research, PO Box 120, Cleveland, Queensland 4163, Australia

³*Network of Aquaculture Centres in Asia-Pacific*

PO Box 1040, Kasetsart Post Office, Bangkok 10903, Thailand

Abstract

The development of sustainable grouper aquaculture is currently constrained by limited hatchery production which affects fingerling availability. A number of regional initiatives are being developed to address this constraint and to facilitate improved collaboration and coordination of grouper aquaculture research within the Asia-Pacific region. The Australian Centre for International Agricultural Research (ACIAR) and the Network of Aquaculture Centres in Asia-Pacific (NACA) sponsored a Grouper Aquaculture Workshop, held in Bangkok on 7–8 April 1998. The workshop developed a structure for improved cooperation and collaboration among grouper aquaculture researchers in the Asia-Pacific region. A summary of the recommendations from the workshop follows:

1. There is a need for further research to address the constraints to grouper aquaculture technology. Research is needed to address the following topics:
 - a) disease and health issues
 - b) improved larviculture technology
 - c) broodstock management and nutrition
 - d) development of low pollution grow-out diets, and
 - e) definition of nutritional requirements for grow-out diets
2. There is a need to establish a coordinated grouper research program in the Asia-Pacific region. It is proposed that a research program comprising institutional or collaborative projects be established to facilitate this objective.
3. There is a need for improved exchange and dissemination of research findings through dedicated grouper aquaculture sessions at regional conferences and workshops; focussed technical workshops on aspects of grouper aquaculture such as breeding and larviculture, grow-out diet development, and fish health

issues; and reporting of research findings in regional aquaculture magazines and journals, and on the NACA grouper web site.

4. NACA will implement these recommendations in cooperation with other participating institutes by preparing a cooperative grouper aquaculture research and development program based on the outcomes of the workshop.

Implementation of the recommendations of the Bangkok workshop as well as the development of other regional initiatives to facilitate improved coordination and communication amongst grouper aquaculture researchers in the Asia-Pacific region are further discussed.

Introduction

Groupers are fishes of high economic importance. There is considerable interest in the development of grouper aquaculture around the world, particularly in the Asia-Pacific region. This interest has been stimulated by several factors:

- High demand and relatively high prices for groupers in local and export markets
- Environmental impacts associated with capture fisheries for groupers and other high value reef fish species (Johannes and Riepen 1995), and
- It is widely accepted that increased aquaculture production of high value reef fish species would reduce pressure on wild stocks by providing an alternative source of product (Phillips et al. 1997).

The development of sustainable commercial grouper aquaculture has been constrained by many factors, but principally by the limited availability of seed (fry or fingerlings). Throughout most of the Asia-Pacific region, grouper culture is highly dependent on the capture of juvenile fish from the wild to supply seed stock for aquaculture.

Sabah Workshop

In December 1996, the Network of Aquaculture Centres in Asia-Pacific (NACA) held a Regional Workshop on Sustainable Aquaculture of Grouper and Coral Reef Fishes in Sabah, Malaysia. The widespread interest in grouper aquaculture in the region can be illustrated by the representation at this workshop which included participants from Australia, Brunei Darussalam, Hong Kong, India, Indonesia, Malaysia, Philippines, Singapore, Chinese Taipei, Thailand and Vietnam. Participants in the Working Group on Technical Aquaculture Issues examined the status of aquaculture technology for a range of high value reef fish species. There was widespread recognition from workshop participants that further research is necessary to develop reliable and sustainable aquaculture technology for grouper.

Specific recommendations from this workshop were as follows:

- Similar workshops should be held in the future to allow follow-up and examination of progress achieved
- Research coordination at national and international levels should be strengthened to fill gaps in knowledge in need-based areas, and
- The system of exchange and dissemination of information should be improved. It was generally agreed that NACA was in a position to best undertake this role, subject to funding constraints

The last of these recommendations was partly addressed by the development by NACA of an internet site dedicated to grouper aquaculture (<http://www.enaca.org/grouper/>). The other two recommendations are being addressed by activities funded by the Australian Centre for International Agricultural Research (ACIAR) and the Asia-Pacific Economic Cooperation (APEC), and coordinated by NACA.

APEC Grouper Collaborative R&D Program

APEC has recognised the destructive nature of the live reef fish trade and the role that aquaculture can play in alleviating impacts associated with this fishery (Johannes and Riepen 1995, Phillips et al. 1997). APEC's Marine Resources Conservation Working Group held a workshop on the 'Impacts of Destructive Fishing Practices on the Marine Environment' in Hong Kong in December 1997. The recommendations of this workshop included the following:

- Encourage efforts within APEC to develop protocols and capacity for the culture of alternative fish species, including fish health issues, and alternative sources of feed
- Support economically viable and environmentally sustainable aquaculture of live reef fish. Specific action is to actively support, through budget allocations and domestic priority setting, collaborative research of expert centres on alternative sources of live reef fishes that do not depend on wild capture. The purpose is to improve culturing capacity of reef fish species and develop experimental hatchery facilities

Subsequently, APEC has funded a project titled 'Collaborative APEC Research and Development Grouper Network'. This collaborative project with APEC and NACA has the following objectives:

- Protect endangered reefs and reef fish from illegal and dangerous fishing practices
- Develop a new aquaculture industry with significant export potential and economic benefit to stakeholders

- Reduce the reliance on wild-caught fingerlings for aquaculture purposes as capture of wild juveniles is probably unsustainable
- Provide an alternative source of income and employment to people currently engaged in dangerous and illegal fishing practices, and
- Develop the capacity to establish a sustainable grouper aquaculture industry through the establishment of a regional research network

Essential components of the project are as follows:

- The development of regional research priorities will be a major objective of the network
- APEC will fund specific research projects, focusing on three major areas of concern in the development of a grouper aquaculture industry and address issues of destructive fishing practices
- A network of researchers will be established by linking individual research projects to facilitate technical and information exchanges. The network will be coordinated by NACA with APEC funding, and
- APEC and NACA will provide a joint co-ordination authority, which will facilitate links between economies conducting research into grouper aquaculture. NACA will facilitate dissemination of information and negotiate staff exchanges between research facilities

The initial activity for the APEC Collaborative Grouper R&D Program will be a meeting of experts to be held in Hat Yai, southern Thailand, in April 1999. The workshop is expected to have the following outputs:

- An expanded Asia-Pacific Grouper Network, with identified priority activities and responsibilities among researchers, information collation and dissemination and human resources development
- An up-to-date assessment of existing technical knowledge, research in progress and research priorities for the development of sustainable grouper aquaculture, including:
 1. fish health issues including quarantine and certification
 2. food safety and quality, and
 3. marketing trends
- Research project concepts to address identified constraints in the various areas.
- A research plan, comprising individual research projects, to be submitted to APEC for funding consideration. The plan should incorporate specific needs and opportunities for researcher secondments in the APEC region to facilitate development and implementation of priority research and development needs
- Identified key issues in the aquaculture of groupers and live reef fish for future follow-up by APEC network participants

The outputs from the discussions of the expert group will be submitted for consideration and appropriate follow up by the joint APEC Fisheries Working Group and Marine Resources Working Group meeting to be held in May 1999.

Grouper Aquaculture Workshop

In March–April 1998, ACIAR funded a mission by Dr Mike Rimmer (QDPI) and Dr Kevin Williams (Commonwealth Scientific and Industrial Research Organisation [CSIRO], Division of Marine Research). The aim was to develop a research project to target technical constraints in the development of sustainable grouper aquaculture and with NACA, organise and facilitate a Grouper Aquaculture Workshop. The workshop was held in Bangkok on 7–8 April 1998. The workshop was designed to address the issues of research coordination and information exchange amongst laboratories involved in grouper aquaculture research in the Asia-Pacific region. The primary focus of this workshop was to discuss opportunities for collaborative research on grouper aquaculture, and to develop methodologies to enhance collaboration and information exchange between grouper aquaculture researchers in the Asia-Pacific region.

Funding support for participants to attend the workshop was obtained from various sources including ACIAR, UNDP, DANCED and the Bay of Bengal Program. The proceedings of this workshop have been documented (Rimmer et al., 2000). In summary, the following outcomes were achieved:

- The status of grouper aquaculture in the Asia-Pacific region was evaluated. The only substantial hatchery production of juvenile grouper is from Chinese Taipei. Grouper aquaculture in other economies relies primarily on collection of wild seedstock
- Research into the development of aquaculture techniques for groupers was listed
- Areas where additional research into grouper aquaculture is needed were identified. Research topics were prioritised. Research topics proposed under the ACIAR grouper project were regarded as high priorities
- A network of grouper aquaculture researchers (the Asia-Pacific Grouper Network) was established to promote cooperative research and to enhance communication among researchers. Several mechanisms were established to facilitate communication
- A research program consisting of individual projects was agreed upon as a useful model for reducing overlap and increasing coordination amongst grouper aquaculture researchers in the region. This model is to be developed further by NACA in conjunction with regional research and development agencies

Reef Fish Aquaculture R&D Project

In 1995-1996, the Queensland Department of Primary Industries (QDPI) undertook a feasibility study into the development of aquaculture techniques for reef fish species, particularly high-value groupers. The Reef Fish Aquaculture Feasibility Study showed that, although the costs of research and development of reef fish aquaculture in Queensland were high, potential benefits to the state were also high. In response, the Queensland Government has funded an R&D project to develop aquaculture technology for reef fish species, principally groupers. The study will be based at Northern Fisheries Centre (NFC) in Cairns, but will rely on collaborative linkages with a wide range of research providers and industry organisations throughout Australia and overseas.

Three core areas of research will be addressed in the study:

Broodstock maintenance and breeding

This component will concentrate on the development of reliable spawning techniques for target grouper species, including control of the reproductive cycle to support year-round larval production.

Larviculture

Low and irregular survival of larvae remains a significant constraint to the development of sustainable grouper aquaculture technology. This component will investigate larval rearing techniques, with particular emphasis on larval nutrition, in particular, the quality of the larval diet will be investigated with detailed histological and histochemical studies on the development of the digestive tract.

Live prey production

Commonly used live prey organisms (rotifers and brine shrimp) have proven of limited success in the larval rearing of groupers, while other types of live prey organisms, particularly copepods, have shown considerable potential. This component of the project will concentrate on the development of new prey types, such as copepods, to supplement or replace rotifers and brine shrimp in larval rearing.

ACIAR Grouper Aquaculture Project

ACIAR supports collaborative research between Australian and overseas research organisations. Because of the interest in, and commitment to, grouper aquaculture in the Asia-Pacific region, ACIAR has supported the development of a collaborative project on improved hatchery and grow-out technology for grouper aquaculture in the

Asia-Pacific region to overcome some of the constraints that have limited the development of grouper aquaculture to date. The ACIAR project will have three major components:

Larval Rearing of Groupers

The overall objective of this component is to improve the growth and survival of groupers during the hatchery phase. The research will concentrate on developing an understanding of the capacity of grouper larvae to digest various live prey organisms, and the nutritional requirements that must be met by live prey. This information will be used to assess the suitability of different live prey organisms at different stages of the larval rearing process, and develop improved nutritional profiles for live prey organisms. These results will be integrated with other studies on environmental factors affecting grouper larvae to develop an improved methodology for larval rearing of groupers.

Diet Development for On-growing of Grouper

The overall objective of this component is to develop compound feeds for grow-out that have low environmental impact, low content of food-grade fishery resource, and are efficacious for the out-growing of grouper as the alternative of using trash fish. This will be addressed in a structured way, acquiring nutritional information on feeds available for diet manufacture, characterising the requirements of groupers for key nutrients, and demonstrating the cost effectiveness of the compounded feeds.

Support for the Grouper Aquaculture Research and Development Program

NACA will facilitate communication amongst grouper aquaculture researchers by collecting research findings from participating institutions, compiling and publishing this information in regional aquaculture magazines, and through expansion of the NACA grouper web site. NACA, in cooperation with participating institutions, will facilitate cooperation in grouper aquaculture research and development based on the recommendations and specific research detailed in the proceedings of the Grouper Aquaculture Workshop held in Bangkok in April 1998. NACA, in cooperation with participating institutions, will continue to seek funding support for specific projects under the Grouper Aquaculture Research and Development Program, with particular emphasis on the development of regional collaborative research and development projects.

Participating agencies and an outline of their activities with regard to the project are:

- Northern Fisheries Centre, Queensland Department of Primary Industries, Cairns, Queensland, Australia, will be responsible for overall project management, and will primarily be involved in larviculture research

- CSIRO Marine Laboratories, Cleveland, Queensland, Australia, will be responsible for management and coordination of the grow-out diet development
- South-East Asian Fisheries Development Centre, Aquaculture Department, Tigbauan, Iloilo, Philippines (SEAFDEC). SEAFDEC will be involved in investigating aspects of larviculture in estuary cod *E. coioides*, and in the development of grow-out diets
- Research Station for Coastal Fisheries, Gondol, Bali, Indonesia (RSCF) will be involved in investigating aspects of larviculture of barramundi cod *Cromileptes altivelis* and flowery cod *Epinephelus fuscoguttatus*
- Research Institute for Coastal Fisheries, Maros, Sulawesi, Indonesia (RICF). RICF will be involved in grow-out aspects of the proposed research, principally investigating grow-out of groupers produced at RSCF and trialing experimental diets
- NACA will facilitate coordination and collaboration of grouper research in the Asia-Pacific region, and facilitate the development of improved extension and information exchange mechanisms

Direct benefits of this research project relate to the improvement of hatchery technology for groupers. The increased supply of grouper fingerlings will support expansion of grouper farming in the region. In response to the anticipated need for greater quantities of feed for aquacultured groupers, compound feeds will be developed to improve the use of fisheries resources, particularly trash fish. Expansion of grouper aquaculture will provide increased job opportunities and economic security both directly (employment in hatcheries and on farms) as well as indirectly (employment by feed and equipment manufacturers).

The project will benefit fisheries resources in the region by reducing reliance on harvesting wild grouper fingerlings. In the medium to long term, expansion of grouper aquaculture is expected to contribute to alleviating pressure on the wild fishery for live grouper product. This live-fish fishery has been associated with environmentally damaging harvest practices such as localised overfishing and the use of sodium cyanide as a capture technique in many parts of Asia and the south Pacific.

The project will also facilitate the development of an international collaborative network of grouper aquaculture researchers with the aim of disseminating research findings rapidly and widely to both other researchers and to industry. The project will provide training and educational opportunities for scientists from partner country agencies.

Asia-Pacific Grouper Network

A central component of the ACIAR and APEC projects will be improved collaboration and coordination of grouper aquaculture research within the Asia-Pacific region.

The Grouper Aquaculture Workshop held in Bangkok on 7–8 April 1998, saw the formation of the Asia-Pacific Grouper Network as a mechanism for improving communication amongst grouper aquaculture researchers.

Workshop Recommendations

During the final session of the Bangkok Grouper Aquaculture workshop, there was considerable discussion on how to further grouper aquaculture research and development in the region, and how to facilitate the continued development of an Asia-Pacific Grouper Network. The following recommendations were agreed upon by workshop participants:

- There is a need for further research to address the constraints to grouper aquaculture technology. Research is required to address specific topics:
 - a) disease and health issues
 - b) improved larviculture technology
 - c) broodstock management and nutrition
 - d) development of low pollution grow-out diets, and
 - e) definition of nutritional requirements for grow-out diets

The outcomes of this research should be incorporated where possible into ‘best practice’ guidelines for grouper aquaculture and efforts should be made to include such guidelines into practical aquaculture extension activities.

Grouper diseases already cause substantial economic losses during grow-out. The regional capacity for marine fish disease control should be improved, and development of a regional diagnostic centre, particularly for viral diseases, was considered a high priority.

- There is a need to establish a coordinated grouper research program in the Asia-Pacific region. This could be facilitated by:
 - a) establishment of a research program comprising institutional or collaborative projects to address the key issues identified in this workshop – facilitated by NACA in cooperation with other organisations and institutes such as APEC, AIT, SEAFDEC
 - b) agreements by institutions to participate in a regional coordinated research program on grouper aquaculture technology development
 - c) additional training opportunities, for example through staff exchanges and short-term attachments at participating institutions
- There is a need for improved exchange and dissemination of grouper research findings. This could be facilitated by:
 - a) institutional support for researchers to attend grouper aquaculture sessions at regional conferences and workshops

- b) focused technical workshops on aspects of grouper aquaculture such as breeding and larviculture, grow-out diet development, and fish health issues
- c) reporting of research findings in regional aquaculture magazines (Asian Aquaculture and Aquaculture Asia) and journals, and on the NACA grouper web site

Implementation

- a) NACA, in cooperation with other institutes, will prepare a cooperative grouper aquaculture research and development program based on the above recommendations and specific research needs detailed in this workshop
- b) the research program will be circulated to respective institutes seeking institutional support and commitment
- c) funding support for specific projects will be sought under the grouper aquaculture research and development program

To be successful, the Asia-Pacific Grouper Network will rely heavily on the active cooperation of all participants. While NACA will continue to coordinate activities within the network, the active participation of researchers and research institutes will be vital to the research network achieving its objectives. Already this collaborative approach has generated a lot of interest. Further research cooperation is being planned, in conjunction with ACIAR and APEC. Anyone involved in, or interested in, grouper aquaculture is invited to contact the people below and participate in its activities – or alternatively log on to <http://www.enaca.org/grouper/>.

Further information

For further information on the Asia-Pacific Grouper Network, contact:

Dr Mike Rimmer

Queensland Department of Primary Industries

Northern Fisheries Centre

PO Box 5396, Cairns, Queensland 4870, AUSTRALIA

Phone: +61 (07) 4035 0109; Fax: +61 (07) 4035 1401

E-mail: Mike.Rimmer@dpi.qld.gov.au

Dr Kevin Williams

CSIRO Division of Marine Research

PO Box 120, Cleveland, Queensland 4163, AUSTRALIA

Phone: +61 (07) 3826 7284; Fax: +61 (07) 3826 7222

E-mail: kevin.williams@marine.csiro.au

Mr Hassanai Kongkeo and Dr Michael Phillips
Network of Aquaculture Centres in Asia-Pacific
PO Box 1040, Kasetsart Post Office
Bangkok 10903, THAILAND
Phone: +66 2 561 1728 / 9; Fax +66 2 561 1727
Email naca@enaca.org or grouper@enaca.org

References

- Johannes, R.E. and Riepen, M. (1995).** 'Environmental, economic, and social implications of the live reef fish trade in Asia and the western Pacific'. Report to the Nature Conservancy and the South Pacific Forum Fisheries Agency. 82 pp.
- Phillips, M. Rimmer, M. and Busing, R. (1997).** Marine fish aquaculture and its potential to alleviate negative impacts of destructive fishing practices. In: Proceedings of the APEC Workshop on Impacts of Destructive Fishing Practices on the Marine Environment, held in Hong Kong, China, 16–18 December 1997 (in press).
- Rimmer, M.A. Williams, K.C. and Phillips, M.J. (2000).** Proceedings of the Grouper Aquaculture Research Workshop held in Bangkok, Thailand, 7-8 April 1998.

5.7 Grouper Aquaculture in the Philippines

Westly R. Rosario

Bureau of Fisheries and Aquatic Resources

National Integrated Fisheries Technology Development Center, Dagapon City, Philippines

Abstract

Grouper has the highest commercial value among fish species in the Philippines. It is a preferred species in the live reef fish trade in Asia. Although relatively new, the culture of grouper in ponds and cages is becoming popular in the Philippines. The demand for grouper dead or live is quite large and peaks from October to March when most Philippines festivities take place.

BFAR reported production of 496 mt of grouper from brackish water ponds and 109 mt from marine fish cages in 1997. The culture of grouper in cages was very popular in regions IV, VI, VII, and XI. Although unreported, grouper culture is also widely practiced in northern and central Luzon.

Aquaculture Constraints

The production of grouper in the Philippines is constrained by several factors:

Grow-out technology is not widely adopted in regions because of the limited supply of grouper fingerlings. Regions with seeds caught in the wild are the only ones active in producing grouper. Grouper hatchery technology needs to be improved and adapted by government centers and private entrepreneurs for semi-commercial production of fingerlings.

Risks due to natural calamities in Northern Philippines are preventing investors from expanding grouper cage culture. This may explain why almost 75% of grouper production in 1997 was produced in the Davao area where typhoons are infrequent.

Groupers are carnivorous. They are fed with trash fish in grow-out culture. The availability of trash fish is uncertain and the prices fluctuate from PhP 10 to PhP 13 per kg. Lower trash fish prices would increase the profitability of grouper culture while higher costs jeopardize the return on investment.

Present Government Interventions

The Philippines Bureau of Fisheries and Aquatic Resources is aware of the constraints to the grouper aquaculture industry in the Philippines. Several major programs and applied research initiatives are implemented:

Applied research on fingerling production and development of additional broodstock

Development of a viable grouper hatchery technology in BFAR National Technology Center started in 1998 and has shown promising results. Grouper are spawned in 40-ton canvass tanks, eggs are hatched in 10-ton tanks. Larvae are fed with natural food. Hatchery and natural food facilities are improved, and earthen ponds are constructed for hatchery and nursery purposes.

Improved engineering designs

The government is encouraging the National Technology Centers and the private sector to develop cage designs with low construction costs that can withstand adverse climatic conditions.

In 1999, a nationwide sea cage production program was launched by the Department of Agriculture (BFAR). The program was to increase awareness of the improved designed for sea cages. A loan was awarded to an aquaculture engineer to develop suitable models for sea cages.

Alternative food for grouper

Studies are being conducted on the use of mosquito fish as initial or alternative food for juvenile grouper. Initial tests indicated that this fish, which is unpalatable to humans and considered a pest in ponds, is consumable by groupers. The biology of the fish related to reproduction or fecundity at different salinity levels was investigated. Pond culture of grouper with mosquito fish was scheduled to begin in 1999.

The project may decrease the production cost associated with feeding the grouper with trash fish. This approach may also increase the growth rate of juveniles and reduce cannibalism by making live food available to them during the culture period.

5.8 Status and Development of Grouper Aquaculture in Pacific Island Countries

Pierre Labrosse

Secretariat of the Pacific Community

B.P.D5 – 98848 Nouméa Cedex (New Caledonia)

Abstract

The Pacific Islands region is still at an early stage of aquaculture development and there is no significant grouper aquaculture in this area. For this reason, this paper will be focussed on prospects and existing aquaculture research and development projects and, more specifically, grouper aquaculture in Pacific Island Countries.

Situation of Pacific Island Countries Related to Aquaculture

In the past, most aquaculture development has been concentrated on high-value species for export. Compared to East and Southeast Asia, Pacific Islands have a disadvantage in this trade due to the high shipping and feed costs. Farming to supply local markets is often not commercially viable. Both of these constraints are starting to erode aquaculture development in the Pacific Island Countries. Regardless of the constraints, Pacific Islands aquaculture has continued to develop. It is also important not to overlook the success of two aquaculture industries which are of economic significance: black pearl culture in Eastern Polynesia and shrimp aquaculture in New Caledonia.

With the development of specific markets such as live reef fish, the demand for speciality export products continues to rise. However, the wild fishery resources in the Pacific islands are not inexhaustible and the major problem is to find the balance for a sustainable exploitation. The problem becomes even more pronounced when targeted species have a demographic strategy close to the K type, with long lifespans and relatively low fecundity rate. Groupers are likely to be more endangered by fishing activities compared to other species. Aquaculture could be one means to protect wild stocks from the risk of overfishing and to ensure sustainable development. It could also minimize the risk of fish poisoning. Fish poisoning cases were recently reported in Hong Kong SAR following consumption of wild groupers imported live from Kiribati.

Research and Development Projects

There are two projects of applied research on grouper in the Pacific islands. The first project, 'Development of New Artisanal Fisheries Based on the Capture and Culture of Post-larval Coral Reef Fish', started in 1999. It is conducted by ICLARM based in the Solomon Islands. The project focuses on a range of species that are of value to the live reef fish market and aquarium trade. Methods have previously been used for research to capture fish just prior to reef colonization. The concept is that natural reef replenishment should not be affected because fish are harvested before they suffer the high rates of natural mortality associated with settlement. When grouper larvae are available, attempts would be made to rear them first in land tanks, then in grow-out sea cages.

The second project, 'Aquatoll', will be underway in 2000 in New Caledonia, probably by the New Caledonian University. This is a pilot project which will explore extensive larval rearing of marine finfish. The targeted species is the coral trout, *Plectropomus leopardus*. Eggs from wild broodstock will be collected and fertilized *in vitro*. Larval rearing will be carried out in sea-cloth sea cages. This method was developed in Europe by IFREMER, the University of Montpellier and the Marine Biology Institute of Crete. It was used successfully for the culture of some Mediterranean species. The principles of this technique are the use of great rearing volume and the use of natural trophic chains to feed fish during the first larval stages. This method seems to be suitable for species where little information on their biology and ecology is available. Larval rearing conditions are close to natural conditions, therefore better quality juveniles can be expected. This method also suits insular conditions with low investment and operations costs. It tends to reduce the biological, technical and financial risks related to the start of exploitation and to the rearing of new species.

There is also a possibility that the University of the South Pacific will start an aquaculture research program, however, the content of this program is uncertain.

Role of SPC

With the FAO South Pacific Aquaculture Project based in Suva and co-ordinated by Mr Tanaka coming to an end, there will be no regional agency to perform the advisory and experience sharing function on a full time basis. In October 1998, at the SPC mini-RTMF, fisheries departments of SPC member countries endorsed a new initiative for the implementation of a regional strategy for aquaculture. The strategy requires that SPC, in addition to supporting international linkages, would advise on the feasibility of new development or commercial projects in aquaculture, thereby enabling countries to make the best choices.

Conclusion

Aquaculture development in Pacific Island countries should take into account isolation of islands, shortage of technical experience and the lack of biological and ecological information for some species of commercial interest. Therefore, it is important to promote culture methods with low investment and operations costs, as well as the development of exchanges and collaborative ways for research and development.

5.9 Cultured Grouper Diseases in Thailand

Yaowanit Danayadol

*National Institute of Coastal Aquaculture
Kaoseng, Songkhla 90000, Thailand*

Abstract

Parasitic, bacterial and viral diseases frequently infect cultured groupers in Thailand. History of the diseases, their causes, clinical signs and treatments are discussed. White spot and monogenetic trematodes are two main parasitic diseases. Flexibacteriosis is the only bacterial disease reported. Viral nervous necrosis (VNN) commonly infect larvae and juvenile fish, blister disease and iridovirus attack large fish.

Introduction

The grouper, *Epinephelus coioides*, is a popular table fish and widely cultured in Thailand. Culture of this species started in 1983, mainly on the west coast of southern Thailand. Production increased during the subsequent years and reached 1,000 tons per year during 1990-1992. Most grouper production was exported to nearby countries such as China, Hong Kong SAR and Chinese Taipei. In 1993, the production decreased dramatically (85-90%). The decrease was caused by insufficient seed supply due to losses from diseases in fry and fingerlings. One of these diseases was viral nervous necrosis (VNN). Both young and adult fish were attacked by several parasites and bacteria, as well as viruses. This paper provides an overview of the information about causes, prevention and treatments for diseases in grouper culture in Thailand.

Parasitic Diseases

Several parasitic diseases have been well documented.

White Spot Disease

White spot is a skin parasitic disease which occurs at every stage of the grouper life cycle, in particular when the fish have been regularly exposed to highly turbid water. This usually occurs during the monsoon season or after heavy rain. In some years, a large number of hatchery spawners are lost to this parasite. During the initial stages, infected fish usually scrape their bodies on the sides of the tank or pond. Opaque eyes and white spots on the body and gills were subsequently observed. The parasite *Cryptocaryon irritans* was identified from grouper infected with white spot disease.

(Ruangpan and Tubkaew, 1993). Within three days of infection, high mortality (up to 100%) can occur in fish of all sizes.

White spot disease can be treated with 0.10 ppm to 0.15 ppm malachite green mixed with 25 ppm formalin. This is effective during the early stage of infection (Danayadol and Direckbusarakom, 1987).

Monogenetic Trematode Disease

Grouper fingerlings cultured in net cages are infected by these parasitic worms when the water quality is poor. This occurs during the dry season when the salinity is high (33 to 35 ppt). During the initial stages, skin darkening can be observed with external lesions during the later stages. A mortality rate of less than 30% was reported. The *Dactylogyrus* spp. were identified from infected fish (Ruangpan and Tubkeaw, 1993).

The most effective treatment for this parasitic disease is 250 ppm formalin for three days at thirty minutes per day or a continuous bath in 0.3 ppm dipterex for three days.

Bacterial Disease

Flexibacteriosis, a common disease found in both freshwater and marine fishes, is caused by a gliding bacteria, *Flexibacter* sp. in grouper, specifically *F. maritimus*.

A serious outbreak of this disease (also known as the red boil disease), was reported in 1996 (Danayadol et al. 1996). It was named after the clinical signs of scales lost and severe hemorrhaging on the body surface, causing it to resemble boiled skin. A high mortality, greater than 80%, can occur within a week. It was believed that stress from grading was the most significant cause of the disease, making the fish susceptible to bacteria invasion.

F. maritimus shows light tan-colored colonies on cytophaga agar containing 50% to 100% seawater. It is long rod and gram negative. This bacterium grows well at 20-30 °C, and in pH 7 to 8. It exhibits positive reactions to oxidase and catalase and shows a negative reaction on gelatin and arginine. Potassium permanganate and oxytetracycline are actively used for treatment in the infected fish, especially at the early stages (Danayadol et al. 1996).

Viral Diseases

Viruses have recently been reported as the causative agents for diseases in marine fishes in Thailand. Some important viral diseases found in grouper are:

Viral Nervous Necrosis (VNN)

The VNN (or whirling disease) was formerly known as encephalomyelitis in several species, such as barramundi (*Lates calcarifer*, Glazebrook et al. 1990), European seabass (*Dicentrarchus labrax*, Breuil et al. 1991) and in some Japanese fishes (Muroga, 1997). VNN has been detected in cultured grouper since 1983. An important clinical sign is whirl-swimming of infected fish; and the swim bladder is generally hyper-flattened. There are no lesions on the body surface and the only indication of the disease is darkened skin. The infected fish always swim near the surface with their body in a curved position. This disease can occur both in larvae and juvenile fish in hatcheries and sometimes in the grow-out. Larvae and juveniles are generally more susceptible to the disease than fingerlings and adult fish. Mortality of up to 90% was reported in larvae and juveniles within a week of infection but was much lower (2%) in fingerlings and adult fish (Danayadol et al. 1995). The loss of the bigger fish appeared to be related to the damage in the small population from the VNN which occurred earlier.

VNN is caused by a nodavirus that infects the optic nerves and brain of the fish (Danayadol et al. 1995). Infected organs are usually vacuolated due to constant lesion. Homogenated filtrate of the brain or eye can bring about pathogenecity after intra-muscular injection.

VNN was found in grouper fry collected from natural waters along the southern coast of Thailand. A high mortality of greater than 80% occurred during the nursing stage from juvenile to fingerling as a result of VNN outbreak.

Iridovirus Disease

In 1993, a serious outbreak caused by iridovirus occurred in cage culture grow-out areas in the southern part of Thailand (groupers ranging from 20 g to 5 kg). Approximately 90% of total production (one million individual fish) were lost due to this disease. Diseased fish showed no lesions but the body appeared to be pale before their sudden death (Danayadol et al. 1997). This disease struck again in 1994.

Virus particles were found in enlarged macrophage cells in the spleen and head kidney of infected fish. It caused necrosis in hematopoietic tissues, including the appearance of enlarged macrophage cells. Basophilic cells found in the affected organs were also enlarged. Hexagonal shape viruses, 120-135 nm (in diameter), were detected. This virus was shown to have the same DNA sequences as the virus that infected several fish species in Japan (Miyata et al. 1996).

In 1997, a new iridovirus was identified in infected small grouper larvae (1.0 cm to 1.5 cm) (Kasornchandra and Kongpradit, 1997). Infected fish had darkened pectoral fins. The mortality rate (20% to 30%) was lower than in the previous cases. Isolation in

EPC (epithelioma papulosum cyprini) and GF (group fin) cells was successful. This virus had a larger diameter (220 nm to 240 nm). The disease can be transmitted by intra-peritoneal injection and cohabitation of viral cells.

Blister Disease

Outbreaks of blister disease have been observed in grouper fingerlings since 1988. Infected fish exhibit an initial loss of appetite, followed by blisters appearing on the body surface and towards the end, a complete refusal to feed. Although blister disease causes low daily mortality, the mortality rates may reach 60% to 80% within a month.

Kongpradit et al. (1997) reported that this disease is caused by an icosahedral shaped iridovirus, 140 nm to 160 nm (in diameter). Isolation of the virus in GF and EPC cells was possible. Pathogenecity was successful through waterborne transmission of cultured virus. Within five days, infected fish showed signs and the onset of mortality occurred. The mortality rates of experimental transmission were as high as 100% and were experienced within 10 days.

Conclusion

Disease can occur at every stage of grouper culture. It depends on factors relating to both the fish and the environment. Larvae and juvenile fish are more susceptible to diseases than fingerlings and adults. Spot disease is still one of the major diseases causing fish losses in hatcheries. Viral Nervous Necrosis (VNN) caused the heaviest loss in larval and juvenile fish, while blister disease took a higher toll in older fish. At present there is no reliable method to prevent or control viral disease. Many of these diseases, especially VNN or blister disease, have been observed to be related to annual spawning, although malnutrition and high stocking density were also factors. Poor water quality during the dry season appeared to be a factor in iridovirus disease.

As groupers are generally timid, they can be stressed easily even in relatively normal living conditions (Ruanganit and Bunliptanon, 1993). There is still no practical method of handling this fish efficiently and safely in order to minimise mortality or to prevent loss from diseases at each stage of the culture. Development of such techniques is desirable, so research on this aspect for grouper culture should be continued.

References

- Breuil, G. Bonami, J.R. Pepin, J.R. and Pichot, Y. 1991.** Viral infection (Picorna-like virus) associated with mass mortalities in hatchery reared seabass (*Dicentrarchus labrax*) larvae and juveniles. *Aquaculture*, 37:109-116.
- Danayadol, Y. Direkbusarakom, S. and Supamattaya, K. 1995.** Viral Nervous Necrosis in browspotted grouper, *Epinephelus malabaricus*, cultured in Thailand. P227-233. *In: Diseases in Asian Aquaculture II.* Edited by Shariffs, M. Arthur, J.R. and Subasinghe, R.P. Fish Health Section. Asian Fisheries Society. Manila.
- Danayadol, Y. Krachaiwong, V. Ruangpan, L. and Direkbusarakom, S. 1996.** Causative agent and control measures for red boil disease in cultured grouper (*Epinephelus malabaricus*). *Thai Fisheries Gazette*, 49(1):29-35. (in Thai, English Abstract) .
- Danayadol, Y and Direkbusarakom, S. (1987).** The disease of grouper (*Epinephelus malabaricus*) (Bloch & Schneider) in the east coast of the Southern Thailand. National Institute of Coastal Aquaculture. Contribution No. 1/1987. 6 p.
- Danayadol, Y. Direkbusarakom, S. Boonyaratpalin, S, Miyazaki, T. and Miyata, M. 1997.** Iridovirus infection in brownspotted grouper (*Epinephelus malabaricus*) cultured in Thailand. P 67 – 72. *In : Diseases in Asian Aquaculture III.* Edited by Flegel, T.W. and MacRae, I. H. Fish Health Section, Asian Fisheries Society. Manila.
- Glazebrook, J.S. Heasman, M.P. and de Beer, S.W. 1990.** Picorna-like viral particles associated with mass mortalities in larval barramundi, *Lates calcarifer* Bloch. *Journal of Fish Diseases*, 13:245 – 249.
- Kasornchandra, J. and Kongpradit, R. 1997.** Isolation and preliminary characterization of a pathogenic iridovirus in nursing grouper, *Epinephelus malabaricus*. P 60 – 66. *In : Disease in Asian Aquaculture III*, edited by Flege. T.W. and MacRae. Ian. H. Fish Health Section, Asian Fisheries Society. Manila.
- Kongpradit, R. Kasornchandra, J. Krachaiwong, V. and Boonyaratpalin, S. 1997.** Blister disease in Malabar grouper, *Epinephelus malabaricus*: Isolation and some characterization of causative agents. Technical paper No. 9/1997. National Institute of Coastal Aquaculture. Department of Fisheries. Songkhal. Thailand 14 p. (in Thai, English Abstract)
- Miyata M. Matsuno K. Jung S.J. Danayadol, Y. and Miyazaki T. 1996.** Genetic similarity of iridoviruses in Japan and Thailand. *Journal of Fish Diseases*, 20:127-134.
- Muroga, K. 1997.** Recent advances in infectious diseases of marine fish with particular reference to the case in Japan. P 21-31. *In: Disease in Asian Aquaculture III*, edited by Flegel, T. W. and MacRae. Ian. H. Fish Health Section, Asian Fisheries Society. Manila.
- Ruangpanit, N. and Bunliptanon, P. 1993.** Some factors affecting the growth and survival rate of grouper larvae, *Epinephelus malabaricus*, Technical paper No. 20/1993. National Institute of Coastal Aquaculture. Songkhla, Thailand. 25 p. (in Thai, English Abstract).

Ruangpan, L and R. Tubkaew 1993. Parasites of the cage cultured grouper, *Epinephelus malabaricus*, in Thailand. P 106-111. *In:* The Proceedings of Grouper Culture, Edited by Research Team of National Institute of Coastal Aquaculture. Songkhla, Thailand.

5.10 Fish Disease, Quarantine and Certification in Thailand

Dr. Somkiat Kanchanakhan

*Aquatic Animal Health Research Institute (AAHRI)
Department of Fisheries, Bangkok 10900, Thailand*

Abstract

This paper provides an overview on aquatic animals diseases and their economic importance in Thailand aquaculture. It also describes the current status of disease surveillance and the reporting systems. The current status of the aquatic health certification programs are provided, major disease problems for aquatic animals in Thailand are also provided.

Overview of Aquatic Organisms and Disease Problems of Economic Importance in Thailand

Bacterial Diseases

- Vibriosis causes septicemia in brackish water and marine fish including shrimp;
- *Streptococcus* and *Pseudomonas* infection cause septicaemia in fish with moderate to high losses;
- Columnaris disease causes problems in many cultured fish species such as seabass, grouper, snakehead, hybrid catfish, sand goby and aquarium fish; and
- *Aeromonas hydrophila* infection is very common in freshwater aquaculture showing clinical signs of haemorrhagic septicaemia. Losses are high at farms with poor water quality. The affected animals are fish, frogs and soft-shell turtles.

Protozoa Parasites

- Ciliated and flagellated protozoa cause severe losses of fish fry in nursing ponds;
- Sporozoa cause mild to severe mortality of freshwater fish in cage culture systems;
- Monogenetic trematode: Most of the parasites from this group are *Dactylogyrus* and *Gyrodactylus*. They usually cause disease with some degree of mortality in fry and juvenile fish;

Crustacean parasites

This group of parasites weakens the fish host, which can easily lead to bacterial infection. The losses may be low. In some cases, especially if a combined pathogen infection occurs, the losses will be high; and

Fungal disease

Aphanomyces invadans has been recorded as the causative agent of epizootic ulcerative syndrome (EUS). Losses in affected fresh and brackish water fish are very high

Current Status of Disease Surveillance and Reporting Systems

EUS is covered by the disease surveillance and reporting system in Thailand which has fisheries biologists or fisheries extension workers based in all 75 provinces. The DOF staff are required to report information on aquatic animal diseases to provincial fisheries officers. The information is passed to DOF in Bangkok. DOF notify AAHRI. Alternatively, AAHRI may receive the disease information directly from provincial DOF staff. AAHRI is responsible for identification and confirmation of EUS and for reporting it to the DOF. DOF makes an announcement and defines the affected area to prevent the movement of diseased fish. This approach has been used for EUS outbreaks since 1980. In the absence of serious disease outbreaks, fish are allowed to be moved anywhere within the country.

Constraints Caused by Introductions and Transfers of Aquatic Organisms

There is some evidence that two new genus/species of parasites and one bacterium might have been introduced with imported fish. These are: *Lernaea* from Chinese carp, *Hexamita* from discus (aquarium fish) and *Edwardsella ictaluri* from American channel catfish.

Mycobacteriosis or nontuberculous mycobacteria is the only fish disease transmitted to humans. Clinical signs of the disease in humans is limited to skin lesions on the hands of some workers on fighting fish farms in Central Thailand. Another case was recorded as an accidental injection with a pure culture of *Mycobacterium marinum* in a laboratory.

Relevant Policy and Legislation

The government of Thailand has 18 regulations on movement of certain aquatic animal species both for import and export.

Table 1: Major diseases in Thailand (1999)

Catfish (hybrid catfish)	<ul style="list-style-type: none"> • Protozoan parasites • Columnaris disease • Epizootic ulcerative syndrome (EUS) • Mycobacteriosis • Aeromonas
Gourami fish	<ul style="list-style-type: none"> • Protozoan parasites • Pseudomonas spp. • Aeromonas • Crustacean parasites • E. tarda
Giant freshwater prawn	<ul style="list-style-type: none"> • Black-gill disease • Body and walking leg erosion
Frog	<ul style="list-style-type: none"> • Aeromonas • Iridovirus
Soft shell turtle	<ul style="list-style-type: none"> • Aeromonas • Protozoan parasites
Giant tiger prawn	<ul style="list-style-type: none"> • White spot disease • Yello head disease • Vibriosis
Grouper and seabass	<ul style="list-style-type: none"> • Vibriosis • Columnaris • Viral diseases

Current Status of Aquatic Health Certification Programs

DOF controls or regulates introduction and transfers of aquatic organisms, including import and export of live aquatic organisms. To bring live aquatic animals into Thailand, the importer must present a health certificate to the Aquatic Animal Disease Control Unit at the airport. For export to other countries, the exporter is not required to present a health certificate. The exporter must approach the appropriate institution if they want a health certificate.

To obtain a certificate, the exporter must submit a fish sample to an authorized office for examination. Authorized offices are located near the airports, in Bangkok (AAHRI), Songkhla, and Phuket. The samples have to be in proportion to the export volume:

1% of the total, if exporting more than 500 fish

3% of the total, if exporting more than 100 but less 500 fish

5% of the total, if exporting less than 100 fish

Fish samples have to be submitted prior to export. The examination process takes one to two days before the certificate can be issued. The certificate is valid for seven days.

DOF is setting up a “one-stop service center” near Bangkok airport for exporting aquarium fish. This center will have many aquarium for exporting companies to hold their fish. The center will also operate a disease diagnostic laboratory. The fish will be checked by a Fish Pathologist for infectious diseases. The fish will be packed and sealed and then moved directly into the air cargo area without further checking.

Existing Facilities for Aquatic Health Certification

- Aquatic Animal Health Research Institute, Bangkok;
- Fish Disease Unit, National Institute of Coastal Aquaculture, Songkhla; and
- Andaman Center for Marine Shrimp Research and Development, Phuket

5.11 Natural Spawning and Larval Rearing of Barramundi Cod Grouper, *Cromileptes altivelis* in Tanks

Ketut Sugama¹, Trijoko¹ Wardoyo¹, John H. Hutapea¹, and Shigeru Kumagai²

¹Central Research Institute for Fisheries of Indonesia

²Japan International Cooperation Agency (JICA), Multispecies Hatchery Project ATA-379. Gondol Research Station for Coastal Fisheries, PO Box 140 Singaraja, Bali, Indonesia.

Abstract

*This is the first report on the successful natural spawning and larval rearing of Barramundi cod grouper, *Cromileptes altivelis* in captivity. Wild-caught broodstock were spawned in captivity at water temperatures of 26–28° C, with a flow-through system of seawater exchange at a rate of 300% per day. Spontaneous spawning occurred successively four to ten times a month from May to October (1996) and mostly occurred during the new moon phase. The number of eggs collected was 0.4 to 4.2 million, fertilization of floating eggs was 80% to 98%, and hatching ranged from 10.3% to 85.7%.*

*The hatched larvae were reared in 10m³ rectangular cement tanks and initially fed on rotifer (*Brachionus plicatilis* SS type), followed by rotifer S type and finally by *Artemia nauplii* mixed with artificial diet. Larviculture trials to fifty days produced juveniles of 23.6mm to 25.3 mm average length, at a survival rate ranging from 2.63% to 5.13%. High mortality of the larvae occurred during the initial three to six days, long spines stages ten to twenty-two days and cannibalism; thirty days after hatching. The results demonstrated the possibility of breeding *Cromileptes altivelis* under captive culture conditions. However, methods to improve the larval survival have to be developed further for commercial farming of this species*

Introduction

The grouper has a high market value in several countries, especially in Southeast Asia, China and Australia. In Southeast Asia, groupers are farmed using floating net cages or earthen ponds (Sugama et al. 1986, Kohno et al. 1988, Chou and Lee 1997, 1997, Yashiro, 1998). However, aquaculture of groupers is in the early stages of development since the major constraint for large-scale commercial farming is the shortage of fingerlings. Although there are several reports on the breeding and larviculture of groupers, controlled breeding and hatchery production of grouper fingerlings for commer-

cial farming is rare due to several technical constraints and poor larval survival (Kohno et al. 1988, Toledo et al. 1993, Watanabe et al. 1995, Hassin, 1997, James et al. 1997, Ruangpanit, 1998, Sugama et al. 1998). Most grow-out systems for groupers depend on seed collected from the wild (Chou and Lee, 1997, Sugama et al. 1986). The shortage of fry, high market value and scarcity of fingerlings from the wild have encouraged the Gondol Research Station for Coastal Fisheries (GRSCF) under the Central Research Institute for Fisheries of Indonesia (CRIFI) and Japan International Cooperation Agency (JICA) to initiate research and development programs on grouper breeding and fry production.

Gondol Research Station for Coastal Fisheries (GRSCF) is carrying out research and development on hatchery and breeding of groupers such as estuarine grouper (*Epinephelus coioides*), malabar grouper (*E. malabaricus*), tiger grouper (*E. fuscoguttatus*), camouflage grouper (*E. polyphkadion*), coral trout (*Plectropomus leopardus*) and polka dot or humpback or barramundi cod grouper (*Cromileptes altivelis*).

Among these groupers, the barramundi cod (*C. altivelis*) is the most expensive species. There is high demand for barramundi cod in juvenile stage (5 cm to 10 cm) as ornamental fish. They have been exported to the USA, Singapore and Hong Kong. In Indonesia, the price of a barramundi cod juvenile was US\$ 1 and in Singapore or Australia it was US\$ 8 to US\$ 10. This is the first report on the successful year-round natural spawning of *Cromileptes altivelis* in captivity and hatchery larval rearing of this species.

Materials and Methods

Breeding of Barramundi Cod, Cromileptes altivelis

Research on domestication and breeding of Barramundi cod *C. altivelis* at Gondol Research Station for Coastal Fisheries was initiated in 1995. Barramundi cod broodstock were collected from the wild and acclimated to captivity for about two weeks before being stocked in a 100-ton circular maturation tank. All fish were treated with a thirty minutes freshwater bath followed by a 30 ppm formalin bath for twenty-four hours to remove unidentified external parasites. In order to prevent bacterial infections, all fish were treated with 100 ppm iodine (Alfazu) for one hour. The male-female ratio in the maturation tank was 1:5. Mature females were smaller than males and weighed between 1.48 kg and 2.30 kg. Male broodstock weighed between 2.90 kg and 3.40 kg. Thirty-six fish were kept in the maturation tank, where they were conditioned to spawn through environmental and feed manipulation. The maturation tanks were equipped with a water inlet and outlet and an aeration system. The water in the maturation tank was maintained at two meters and the water was allowed to flow through to achieve a 200% to 300% per day water exchange. Broodstock were fed fresh and frozen fish

(mainly *Sardinella* sp) and squid once daily to satiation. The diet was supplemented with a vitamin and mineral mix at 1% of diet.

The broodstock were allowed to spawn naturally. Whenever spawning occurred, the fertilized eggs were collected using a 200-mm mesh size plankton net, which was placed in the overflowing outlet of tank. The eggs were washed with clean water and transferred to a 100-litre tank to check the quantity of buoyant and sunken eggs. The sunken eggs were kept in a one to two ton hatching tank, which was moderately aerated. Newly hatched larvae were transferred to a larval rearing tank.

Larval Rearing

The newly hatched larvae, four to six hours old, were stocked in a 10-ton larval rearing tank at an initial rate of 10 to 15 larvae per litre. The seawater used in the hatchery was pre-treated using sand filters. The salinity was 33 ppt to 34 ppt at a water temperature of 28-30°C. The larval rearing was carried out in the same tanks throughout the larval rearing of fifty days. Live food for the larval rearing consisted of the microalga *Nannochloropsis* sp., SS-type rotifers (size 80 to 100µm), S-type rotifer (size 100 to 180µm) and *Artemia* nauplii. The larval rearing protocol is summarized in Figure 1.

The microalga, *Nannochloropsis* sp. was introduced in the larval rearing tanks within twenty-four hours of stocking the larvae. The alga cell density was maintained at 200 to 300 x 10³ cell/ml. from day one to day twenty.

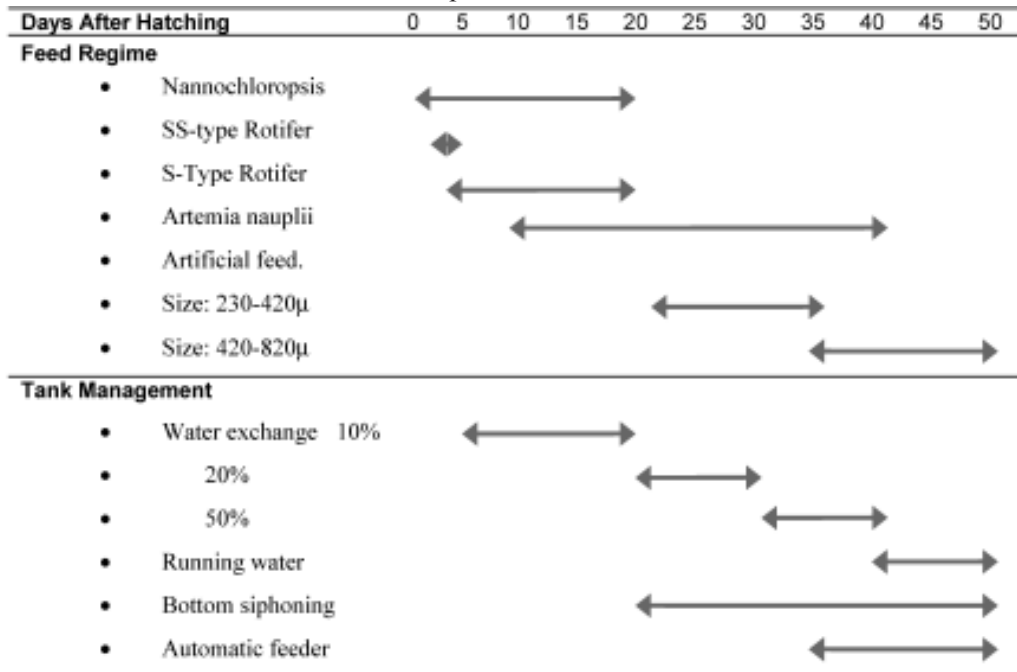
The SS-type rotifers were introduced on day two when the larvae partly absorbed their yolk. The SS-type rotifer density in the larval rearing tanks was maintained at 7 to 10 ind/ml from day two to day five. The S-type rotifers with density of 10 to 15 ind/ml were maintained from day five to day fifteen; and density of rotifers gradually decreased as the rate of rotifer consumption by the larvae decreased. Rotifer disappeared by day twenty.

From day fifteen onward, newly hatched *Artemia* were introduced in the larval rearing tanks. The number of *Artemia* nauplii was increased from 0.1 ind/ml on day fifteen to 0.2 ind/ml on day eighteen. From day eighteen to day forty-five, one-day old *Artemia* were introduced with density of 0.2 to 0.5 ind/ml. Prior to placement in the larval rearing tank, day old *Artemia* were treated with “Yugen” to increase their nutritional values. Yugen is composed of beer yeast cells encapsulating lipid, and is stable at a high temperature. From day twenty, a small amount of commercially formulated diet feed (Nippai, ML Powdered) with particle size of 230 to 420µm was used. The feed size was gradually increased from 420 to 820µm from day twenty to day fifty.

From day twenty to day thirty-five, the larvae were hand fed to satiation with inert feed once in four hours. The amount averaged about 10 g per tank per day. The dispensing

of excess feed was avoided. Automatic belt feeders were used from day thirty-five onwards to gradually dispense the feed over a twelve hour period each day. During this time, the feed amount was adjusted to 20 g per tank per day.

Figure 1: Feed regime and tank management used during the larval rearing of barramundi cod, *Cromileptes altivelis*



Results and Discussion

The first natural spawning of barramundi cod in a concrete tanks was recorded in May and continued to October 1996 (Figure 2). Natural spawning took place every month, mostly in the new moon phase. The fish usually spawned in early morning between 01:00 am and 03:00 am. The total number of eggs released in each spawning were estimated at 0.4 to 4.2 million. The fertilization and hatching rates of floating eggs were 80% to 98% and 10.3% to 88.8% respectively, at an ambient temperature of 28-30°C and seawater at and 33-34 ppt. The incubation period was about eighteen to twenty hours.

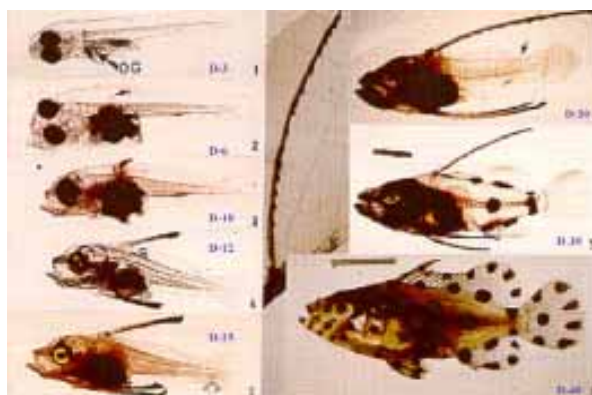
During the early stages of larviculture, the larvae were positively phototactic and aggregated in the bright areas of the larval rearing tanks whenever the algal cell densities decreased in the tank due to active feeding of rotifers on *Nannochloropsis* sp. Maintenance of alga densities of 200 to 300 x 10³ cell/ml was effective in reducing the phototactic behaviour and to disperse the larvae in the culture tank.

The larvae were ingesting SS-type rotifers from day three onward. The active feeding of larvae on S-type rotifers increased from day five and, therefore, increased rotifer densities in the larval rearing tanks to cope with the larval feeding. At day seven, when the larvae reached 3 mm TL, they were supposed to engulf air for their swim bladder inflation. Failure in air gulping may cause malformation of the vertebrae column. The long dorsal and ventral spine had a distinct appearance by day ten or eleven (Kumagai et al. 1998). As the growth proceeded, along with the dorsal and ventral spines many spinelets appeared on the anterior and posterior margins. The melanophores also expanded and darkened (Figure 3). Metamorphosis initiated from day thirty-five onward and all larvae completed metamorphosis by day fifty (Kumagai et al. 1998, Matsuda et al. 1998).

Table 1: Rearing trials of Barramundi cod grouper, fifty days after hatching

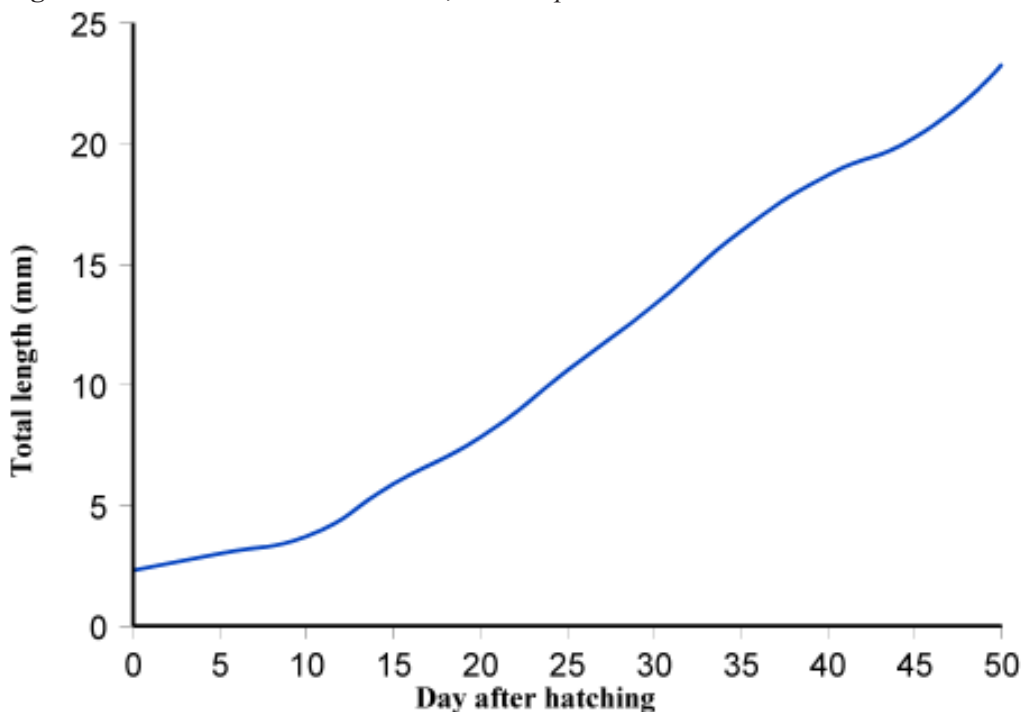
Trial Number	Newly Hatched Larvae	Surviving Juveniles	Survival (%)	Length (cm)
1	125.000	3.310	2.65	2.36
2	100.000	2.880	2.88	2.53
3	100.000	3.204	3.20	2.43
4	100.000	2.630	2.63	2.39
5	142.000	5.545	3.90	2.48
6	100.000	5.131	5.13	2.43
Mean			3.40	2.44

Figure 2: Larval development of barramundi cod *Cromileptes altivelis*



The larval growth was slow at the early stages. The growth curve during the larval rearing period showed a curvilinear pattern (Figure 4). In six trials, the juveniles reached an average length of 2.44 cm after fifty days. The survival rate ranged from 2.63% to 5.13% (Table 1). At day fifty-five, most of the larvae metamorphosed into juveniles with an average length of 2.5 cm and were ready to be harvested. Larvae were scooped gently with a plastic ball together with water and transferred into a container for further transportation.

Figure 3: Growth of barramundi cod, *Cromileptes altivelis* larvae



High mortality of larvae usually occurred during the initial feeding at three to six days; long spine stage from day ten to twenty-two, malformation at day twenty-four and cannibalism thirty days after hatching. The first period of mortality may be caused by poor quality of fertilized eggs, and the second period is mostly caused by mismanagement of water rearing tanks such as strong current or aeration, light intensity and bottom cleaning. Based on our observation, the mortality occurred as follows: some larvae were accidentally trapped by water surface tension (these larvae secreted sticky mucus), other larvae staying near the water surface were stuck to the mucus. Similar situations have been observed in the larval rearing of *Epinephelus coioides* (Kawahara et al. 1995). In many cases, high mortality of the larvae occurred just after bottom cleaning (siphoning). Taking the risk of the mass mortality into consideration, bottom cleaning was performed after the larvae was twenty days old and started to feed on the commercially formulated diet.

The factors which contributed to the larval mortality during rearing period were egg quality, failure of initial feeding, secretion of sticky mucus, long spines, nutritional deficiency, cannibalism and uninflated swim bladder (Figure 6).

The larval survival rate (to the metamorphosis stage) at day fifty was about 3.40%. This is considerably higher than that of *Epinephelus tauvina* (<2%, Lim, 1993) and *Epinephelus malabaricus* (average 3.21%, Ruangpanit et al. 1993). The larval sur-

Figure 4: Mortality pattern of *Cromileptes altivelis* larvae during rearing periods

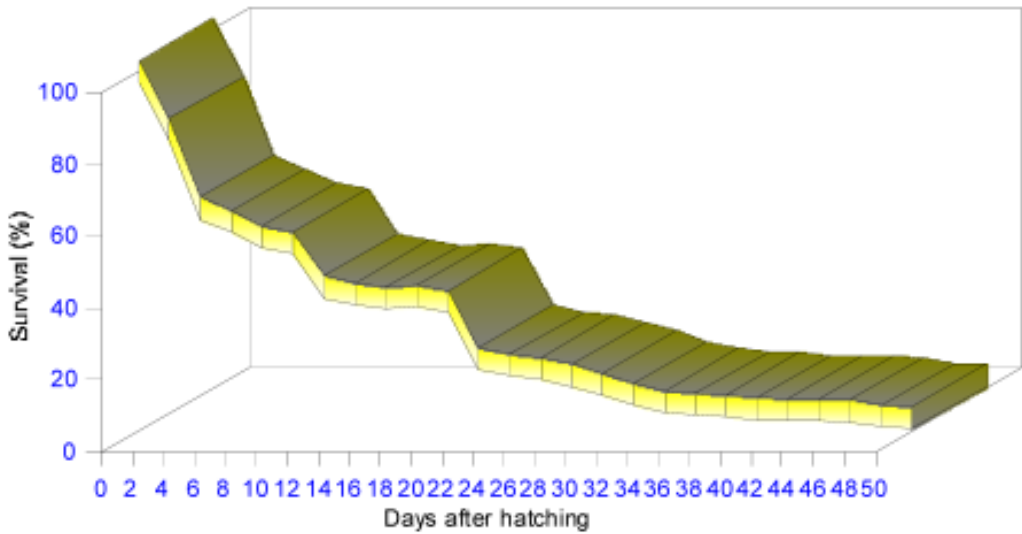
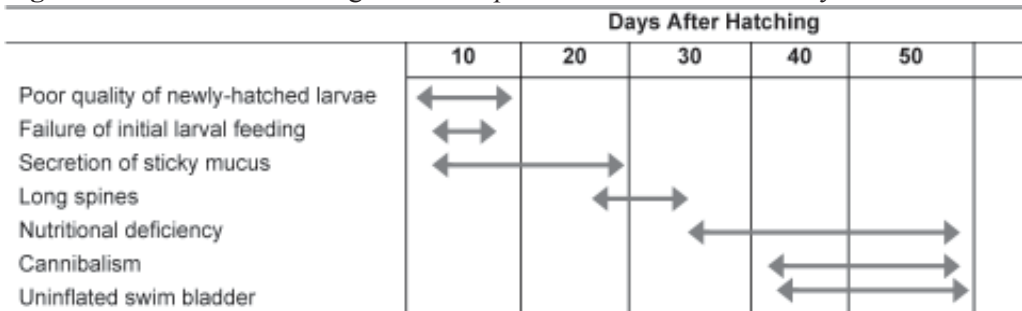


Figure 5: Factors contributing to *Cromileptes altivelis* larval mortality



vival is low compared to the survival rate achieved for *Epinephelus fuscoguttatus* (10%, Lim, 1993).

Conclusion

Cromileptes altivelis readily spawn in captivity without the use of hormones or other treatment. The feeding protocol outlined in this study makes possible a mass production with the survival rate greater than 5% from larvae to juveniles. Further improvements in broodstock management, larval rearing methods, diet formulation, and disease control should improve the survival rate and allow commercial farming of this species.

References

- Chou, R. and H.B. Lee. 1997.** Commercial marine fish farming in Singapore. *Aquaculture Research*, 28:767-776.
- Hassin, S. D. de Monbrison, Y. Hanin, A. Elizeer, Y. Zohar and D.M. Popper. 1997.** Domestication of the white grouper, *Epinephelus areolatus* I. Growth and Reproduction. *Aquaculture*, 156: 305-316.
- James, C.M. S.A. Al-Thobaiti, B.M. Rasem and M.H. Carlos. 1997.** Breeding and larval rearing of camouflage grouper, *Epinephelus polyphekadion* in the hypersaline waters of the Red Sea Coast of Saudi Arabia. *Aquaculture Research*, 28: 671-681.
- Kawahara, S. A.A. Al-Bosta, F.A. Al-Murbaty and A.J. Shams. 1995.** Hatchery production of the groupers *Epinephelus coioides* at National Mariculture Centre Bahrain, DGF, State of Bahrain, 22 pp.
- Kohno, H. M. Duray and J. Juario. 1988.** State of grouper (lapu-lapu) culture in the Philippines. *SEAFDEC Asian Aquaculture*, 10: 4-9.
- Kumagai, S. H. Matsuda, J.H. Hutapea and T. Aslianti. 1998.** Morphological and behavioral development in larval Humpback grouper, *Cromileptes altivelis*. P. 38-45. *In: Seminar Lolitkanta-JICA ATA-379*. Denpasar, 6-7 August 1998.
- Lim, L.C. 1993.** Laviculture of the greasy grouper, *Epinephelus tauvina* & the brown-marbled grouper, *Epinephelus fuscoguttatus* in Singapore. *J. World Aqua. Soc.* 24:262-274.
- Matsuda, H. D. Rohaniawan, B. Slamet and Trijoko. 1998.** A method of seed production for Humpback grouper, *Cromileptes altivelis*. *Lolitkanta-JICA ATA-379*. Booklet No. 1.
- Ruangpanit, N. P. Boonliptanon and J. Kongkumnerd. 1993.** Progress in the propagation and larval rearing of the grouper *Epinephelus malabaricus*. Pp71-82. *In: Grouper culture. The Proceedings of grouper culture.*
- Ruangpanit, N. 1998.** A review of grouper culture (*Epinephelus* spp.) in Thailand. *Grouper Aquaculture Research Workshop, Bangkok Thailand 7-8 April 1998*. 12 p.
- Sugama, K. Waspada and H. Tanaka. 1986.** Growth comparison of some species of groupers in floating net-cages. *Sci. Rep. Res. JICA ATA-192*. 211-214
- Sugama, K. Wardoyo, D. Rohaniawan and H. Matsuda. 1998.** Technology for mass production of *Cromileptes altivelis*. p. 71-88. *In: Seminar Lolitkanta-JICA ATA-379*. Denpasar, 6-7 August 1998.
- Toledo, J.D. A. Nagai and D. Javellana. 1993.** Successive spawning of grouper *Epinephelus suillus* in tank and floating net-cage. *Aquaculture*, 115: 361-367.
- Watanabe, W.O. C.S. Lee, S.C. Ellis and E.P. Ellis. 1995.** Hatchery study of the effects of temperature on eggs and yolk sac larvae of the Nassau grouper *Epinephelus striatus*. *Aquaculture*, 136: 141-147.

Yashiro, R. 1998. Recent status of grouper breeding and larval rearing and nursing of fingerlings to juveniles in Thailand. P. 10. *In:* Grouper Aquaculture Research Workshop Bangkok, Thailand, 7-8 April 1998.

5.12 Grouper Aquaculture in Korea

Lee, Young Don

Marine Research Institute

Cheju National University, Cheju-Do 695-810, Korea

Abstract

In the coastal area of Cheju Island and Southern Sea of Korea, about eleven species of groupers inhabit the rocky reefs, usually from five to 60 m under the water surface.

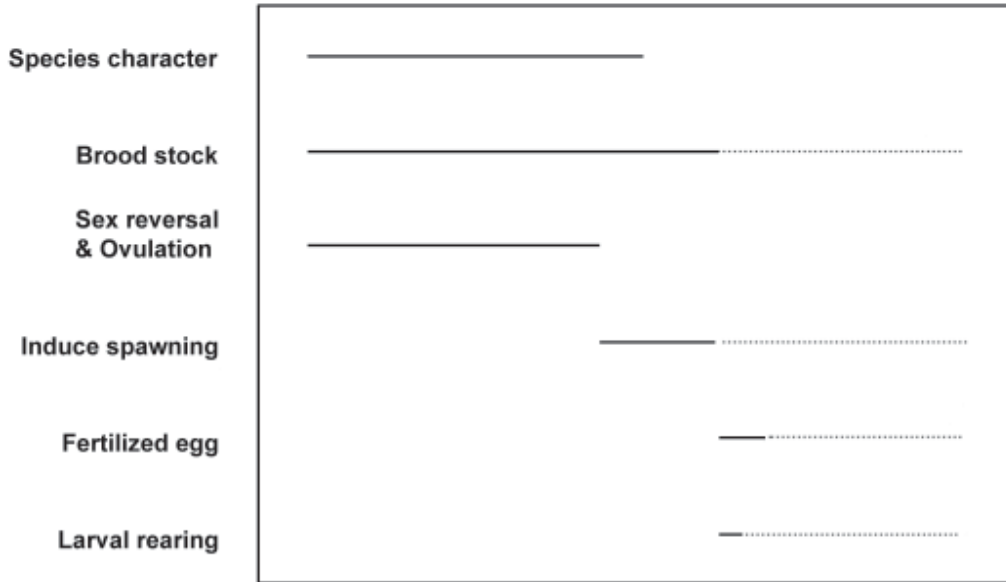
*The most common wild-caught groupers are kelp grouper (*E. bruneus*), sevenband grouper (*E. septemfasciatus*) and red grouper (*E. akaara*). They are very expensive with a market price of US\$100 per kilogram. Their supply has been decreasing due to overfishing with hook-and-line fishing and spear gun. Because of their market value, these species are the most important for future mariculture in Korea. The demand for aquacultured grouper is increasing rapidly and many researchers have been focusing on their reproductive and biological characteristics.*

Fishing of young grouper is closely related to the spawning season and the Kuroshio Current. The spawning season is June to August on the southern coast of Cheju Island. Young grouper move to the Southern Sea along the Kuroshio Current. Groupers are collected by fish traps from May to November. Collected young are raised by net cage culture. The production of grouper aquaculture is about 50 to 100 tonne per year and that of the wild grouper of the sizes from 700 to 3,000 g is about 30 tonnes per year.

*We have attempted sex maturation, sex reversal, spawning induction, and the production of fertilized eggs in groupers (*E. akaara*, *E. septemfasciatus*, *E. bruneus*). We will also research broodstock management for production of the fertilized eggs, development of live-food organisms and culture techniques for larvae and juvenile of grouper.*

Research Flow Diagram

'92 '93 '94 '95 '96 '97 '98 '99 2000 2001



5.13 Recent Developments in Grouper Aquaculture in Hong Kong, China

Jim Chu

*Agriculture and Fisheries Department
Hong Kong SAR Government*

Abstract

This paper describes the development of aquaculture in Hong Kong SAR, with special discussion on the inland pond fisheries, marine fish culture and oyster culture. It also provides information on technical development and services that are available to the fish farmers. The experience on red tide monitoring and management are also briefly discussed.

In Hong Kong aquaculture includes inland pond fish culture, marine fish culture and oyster culture. In 1998 production from the aquaculture sector was 6,164 tonnes valued at \$172 million which was 3 per cent in weight and 8 per cent in value of the total fisheries production.

Inland Pond Fisheries

The inland freshwater fish culture industry is centred in the north-west New Territories. Fish ponds are either freshwater or brackish. In 1998, the local inland ponds, covering an area of approximately 1,110 ha, produced 4,900 tonnes of freshwater fish amounting to \$83 million. About 94 per cent of the farms are engaged in polyculture (bighead carp, silver carp, common carp, grass carp in combination with tilapia or grey mullet). The remaining 6 per cent practice monoculture of carnivorous species: snakehead, sea bass or catfish. Majority of the fry and fingerlings are imported from mainland China, Thailand or Taiwan, while there is some local breeding of snakehead and catfish. Some grey mullet fry may also be caught in local coastal waters. Traditionally, fry are stocked in early spring and most fish species reach marketable size in eight to twelve months.

Marine Fish Culture

Marine fish culture involves rearing of marine fish from fry or fingerlings to marketable size in cages suspended by floating rafts usually in sheltered coastal areas. Common species under culture include gold-lined seabream, brown-spotted grouper, Russell's snapper, mangrove snapper, red snapper, cobia and pompano. Fry are mostly imported from the Mainland, Thailand, Philippine or Indonesia. The species cultured changed gradually over the years depending on the availability of imported fry. Tradi-

tionally, marine cultured fish are fed with trash fish. In recent years, with the department's extension effort, increasing number of marine fish farmers have changed over to use moist or dry pellet feed which significantly reduce pollution caused by fish feed and improves both the feed efficiency as well as fish health.

Marine fish culture is protected and regulated by the Marine Fish Culture Ordinance (Cap. 353) which requires all marine fish culture activity to operate under licence in designated fish culture zones. Currently, there are 26 fish culture zones occupying a total sea area of 209 ha with some 1,480 licensed operators. Majority of the licensed farms are small, family based consisting of one to two rafts with average total area of around 250 m². The serious red tide outbreak in March and April 1998 has resulted in great losses to mariculture farms and a sharp decline in their production. The estimated production in 1998 was only about 1,200 tonnes which catered to about 5 per cent of local demand for live marine fish.

Oyster Culture

Culture of oyster has been practised along the intertidal mud flat of Deep Bay in north western corner of Hong Kong for at least 200 years. Oyster used to be cultured by the bottom culture method with spat collected by laying old shells, rocks or concrete pile or post as clutches on the mud flat in May or June. In recent years, with repeated failure in spat collection, farmers turned to fattening of young oysters imported from the mainland which would take about six to twelve months before marketing. For operation convenience and faster growth, fattening is carried out mostly by raft culture. Production in 1998 is only about 64 tonnes valued at \$4 million.

Technical Development and Services to Fish Farmers

Adaptive development studies are conducted to improve productivity and enhance sustainability of the local aquaculture industry. To provide greater variety of choice of species for culture and to reduce market competition, effort is made to identify suitable new species with good market potential for extension to farmers. Culture trial of red drum have shown that this species can be grown in marine and near fresh water conditions and is currently cultured by a few fish farmers. Another species under trial is the giant grouper.

Fish feed is identified to be a major factor affecting the degree of self pollution of the fish culture environment as well as the health and growth of the cultured fish. Efforts are being made to improve the feed formulation to reduce the polluting effect as well as to increase the feed efficiency. Moist pellet feed comprised trash fish, fish meal, vitamin mixture and binder was developed and has been extended to marine fish farmers since 1994. This moist pellet feed significantly reduces wastage and leaching and achieved a feed conversion ratio of around three in comparison to the ratio of about eight to ten for

trash fish. A feed for the local rabbit fish, a recent new species under culture, was also successfully formulated.

Requests for assistance on fish culture techniques and management problems are dealt with as soon as possible. Detailed investigations are carried out and technical advice on possible measures to overcome or minimize the problem is provided to fish farmers. Fish disease has been a difficult problem encountered by fish farmers. Upon request, this department provides assistance in disease diagnosis and advice on appropriate treatment measures. In Hong Kong, fish disease outbreaks were mainly caused by pathogenic bacteria or parasitic protozoa as well as problems related to water quality and husbandry practice of the fish farms.

Initiatives are also taken to extend improved culture and management techniques to fish farmers. Visits to fish farms are made regularly. Technical seminars and demonstrations are conducted to introduce and promote improved farming technique e.g. moist or dry pellet feed. Information on fish farming management and environmental hygiene is also disseminated through advisory leaflets and guidelines.

Monitoring and Management of Red Tide

Since May 1998, the Agriculture, Fisheries and Conservation Department has launched an intensive phytoplankton monitoring programme to sample the waters regularly at various locations to detect the presence of harmful algal species and development of red tides. The aim of this programme is to provide early warning to fish farmers and to advise them on precautionary measures to reduce loss before the red tide/harmful algal bloom has developed to a level harmful to the fish.

In collaboration with the Federation of Hong Kong Aquaculture Association, we helped the mariculturists to set up support groups in fish culture zones to expedite dissemination of red tide warnings using a flag-code system, to assist in monitoring the red tide situation in fish culture zones and to co-ordinate raft relocation and other remedial actions as appropriate.

An Interdepartmental Red Tide Working Group has been set up in July 1999 for the monitoring and management of red tides in Hong Kong. For more information about red tides/harmful algal blooms (HABs) and the roles of relevant Government departments in the management of such phenomena, please visit our Red Tide Webpages (<http://www.info.gov.hk/afd>). The latest red tide situation in Hong Kong waters is regularly updated on the web.

5.14 Overview of Grouper Production Technology in the Asia-Pacific Region

Michael A. Rimmer

Queensland Department of Primary Industries

Northern Fisheries Centre, PO Box 5396, Cairns, Queensland 4870, Australia

Abstract

This paper provides an overview of the grouper production technology in the Asia-Pacific region, and researches needed for grouper aquaculture development. This paper summarises the information that was collated during a Grouper Aquaculture Research Workshop, held in Bangkok on 7–8 April 1998. Full details are being published in the Proceedings of the Grouper Aquaculture Research Workshop, Bangkok.

Introduction

The development of sustainable grouper aquaculture is currently constrained by limited hatchery production resulting in low fingerling availability. A number of regional initiatives are being developed to address this constraint and to facilitate improved collaboration and coordination of grouper aquaculture research within the Asia-Pacific region. One such initiative is the Australian Centre for International Agricultural Research (ACIAR) project to develop improved grouper aquaculture techniques. A component of this project is the facilitation of improved collaboration and coordination of grouper aquaculture research within the Asia-Pacific region, through the development of a network of grouper aquaculture researchers facilitated by the Network of Aquaculture Centres in Asia-Pacific. The initial activity of this project was a Grouper Aquaculture Workshop, held in Bangkok on 7–8 April 1998, which was attended by researchers from economies throughout the Asia-Pacific region.

The Bangkok workshop developed a structure for improved cooperation and collaboration among grouper aquaculture researchers in the Asia-Pacific region. A summary of the recommendations from the workshop is as follows:

- There is a need for further research to address the constraints to grouper aquaculture technology. Research is needed to address the following topics:
 - a) disease and health issues
 - b) improved larviculture technology
 - c) broodstock management and nutrition
 - d) development of low pollution grow-out diets, and

- e) definition of nutritional requirements for grow-out diets
- There is a need to establish a coordinated grouper research program in the Asia-Pacific region. It is proposed that a research program comprising institutional or collaborative projects be established to facilitate this objective.
- There is a need for improved exchange and dissemination of grouper research findings through dedicated grouper aquaculture sessions at regional conferences and workshops; focussed technical workshops on aspects of grouper aquaculture such as breeding and larviculture, grow-out diet development, and fish health issues; and reporting of findings in regional aquaculture magazines and journals, and on the NACA grouper web site.
- NACA will implement these recommendations in cooperation with other participating institutes by preparing a cooperative grouper aquaculture research and development program based on the outcomes of the workshop.

A major objective of the Bangkok workshop was to identify research in progress in the Asia-Pacific region with a view to reducing overlap and duplication of research effort, and promoting cooperative research amongst institutions with common interests. The workshop participants evaluated the status of grouper aquaculture in the Asia-Pacific region, identified areas where further research was needed, and assigned priorities (high, medium, low) to these research topics. This paper summarises the information that was collated during the workshop. Full details will be published in the proceedings of the Bangkok workshop.

Table 1: Broodstock

Status	<ul style="list-style-type: none"> • Held in tanks: 20 to 200 m³ • Held in cages: up to 65 m³
Density	<ul style="list-style-type: none"> • 1 to 5 kg/m³ • 0.5 to 3 fish/m³
Sex Ratio	<ul style="list-style-type: none"> • 1 male:1 female to 1 male:10 female • Availability of males limiting for most species
Diet	<ul style="list-style-type: none"> • Primarily trash fish, squid
Research Required	<ul style="list-style-type: none"> • Sex reversal using methyltestosterone (H) • Optimal sex ratio (M)

Table 2: Spawning

Status	<ul style="list-style-type: none"> • Duration, 1 to 18 days per spawning event • Water temperature, 25–32°C (tropical species) • Spawning seasonal variable; some species spawn throughout the year
Hormonal induction	<ul style="list-style-type: none"> • HCG: 200 – 1,000 IU/kg BW • LHRHa / GnRH: 20 – 75 µg/kg BW
Research Required	<ul style="list-style-type: none"> • Annual and seasonal changes in sex steroids, egg quality (H) • Relationship between broodstock diet and egg, larval quality (H) • Hormonal induction: dose rates, application, hormones (M)

Table 3: Fertilisation and hatching

Status	<p>Fertilisation:</p> <ul style="list-style-type: none"> • fertilisation rate variable: 0–90% • varies between spawning nights • development may cease at blastula or gastrula stage, despite high fertilisation <p>Hatching:</p> <ul style="list-style-type: none"> • highly variable, usually >30% • occurs 15–19 hours after fertilisation (tropical species)
---------------	--

Table 4: Larviculture

Status	<ul style="list-style-type: none"> • Poor survival of hatchery-reared groupers is a major constraint to the development of sustainable grouper aquaculture in the Asia-Pacific region • Survival is low (generally <10%) and highly irregular • Figure 1 summarises the general feeding strategies used for larval rearing of groupers
Research Required	<ul style="list-style-type: none"> • Aspects of larval biology (H) • Selection of small strain rotifers (H) • Prey selection, feeding behaviour (H) • Investigate physiology of 'shooters' (M) • Reliable production of copepods (H) • Development of alternative prey (H) • New artificial diets for early larval stages (H) • Causes of swim-bladder and skeletal deformity (H) • Larval digestion and physiology, enzyme development (H) • Define nutritional requirements, particularly fatty acids, vitamins (H) • Role of hormones (e.g. cortisol) in improving initial larval survival (H)

Table 5: Wild-caught seed

Status	<ul style="list-style-type: none"> • Major source of seedstock in Asia-Pacific, with exception of Chinese Taipei • High mortality in wild-caught seed (commonly up to 90%)
Research Required	<ul style="list-style-type: none"> • Use of cortisol to strengthen fry (M) • Nutritional research (M) • Improve methods of collection, transportation, storage (M)

Table 6: Disease

Status	<p>Broodstock</p> <ul style="list-style-type: none"> • protozoan infestations <p>Larvae</p> <ul style="list-style-type: none"> • VNN • <i>Cromileptes</i>, subject to bacterial infections <p>Grow-out</p> <ul style="list-style-type: none"> • Parasites: trematodes, protozoans • Bacterial: <i>Vibrio</i>, others • Viral: sleepy grouper, gas bubble
Research Required	<ul style="list-style-type: none"> • Develop prevention and treatment regimes (H) • Evaluate immunostimulants and probiotics (H) • Development of regional viral disease diagnostic centre (H)

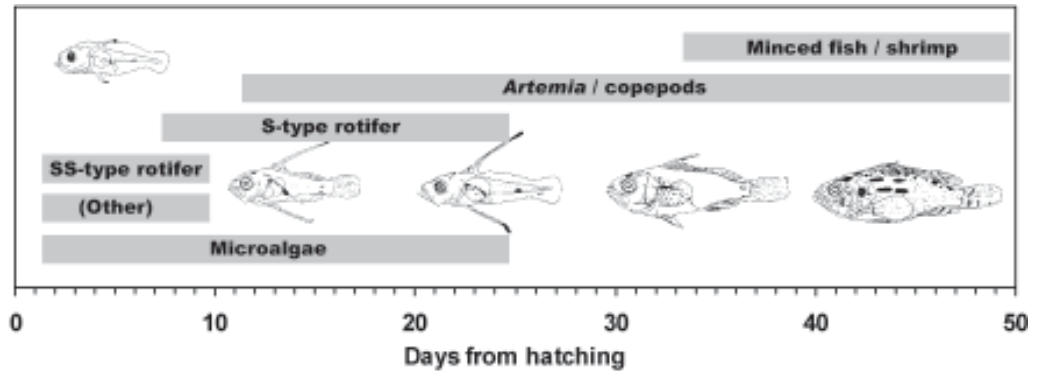
Table 7: Nursery (15-25 mm to 100 mm TL)

Status	<ul style="list-style-type: none"> • Cage culture, some pond culture in Philippines • Density: 50–100 fish/m³ • Cannibalism <ul style="list-style-type: none"> ○ reduced by use of shelters ○ worst with <i>E. fuscoguttatus</i>
Feeds and Feeding	<ul style="list-style-type: none"> • Minced trash fish • Increasing use of artificial (semi-moist) pellets • Disease problems caused by pollution associated with feeds
Research Required	<p>Improved low pollution feeds (H) Disease diagnostics, prevention, and treatment (H)</p>

Table 8: Grow-out (100 mm TL to market size)

Status	<p>Cages</p> <ul style="list-style-type: none"> • stationary and floating, 3–5 m sq. or larger • density: 50–100 fish / m³ <p>Ponds</p> <ul style="list-style-type: none"> • polyculture with tilapia, rabbitfish • density: 5,000 fish / ha <p>Growth</p> <ul style="list-style-type: none"> • 5–6 months to 600–800 g • survival usually 80–90% <p>Market size:</p> <ul style="list-style-type: none"> • plate size 600 g • 1.5–2 kg for <i>E. coioides</i> • > 3 kg for <i>E. lanceolatus</i>
Feeds and Feeding	<ul style="list-style-type: none"> • Trash fish predominant feed • Trend towards semi-moist pellets • Stationary and floating, 3–5 m square or larger • Dry formulated feed limited availability, not well liked by farmers • Regional and seasonal shortages of trash fish, particularly in Indonesia, Hong Kong, Philippines • Feed once or twice daily at 7–8% BW, reducing to 3% BW • FCRs <ul style="list-style-type: none"> ○ 8–10:1 for trash fish ○ 3:1 for semi-moist pellets
Research Required	<ul style="list-style-type: none"> • Develop less polluting feeds (H) • High nutrient diets • Low N & P excretion • Characterise nutritional value of local feed ingredients (H) • Determine essential lipid requirements (H) • Validate applicability of seabass nutritional data for groupers (H) • Feed management (M) • Optimise feeding frequency • Optimise feed pellet (size, buoyancy)

Figure 1: Generalised feedingschedule for grouper larviculture



Other: oyster trochophores, mussel larvae, copepod nauplii, sea urchin eggs, barnacle nauplii.

5.15 Grouper Culture as a Tool in Marine Park Management – A Project of The Nature Conservancy, Indonesia Coastal and Marine Program

Peter J. Mous¹, Jos S. Pet² & Rili Djohani²

¹*The Nature Conservancy Indonesia Coastal and Marine Program*

Komodo Field Office, Kampung Ujung, Labuan Bajo, Flores Barat, NTT Indonesia

²*The Nature Conservancy Indonesia Coastal and Marine Program*

Indonesia Field Office, Jl. Hang Tuah Raya 42, Kebayoran Baru 12120, Jakarta, Indonesia

Abstract

This paper provides information on the activities that have been carried out in Komodo National Park, Indonesia by The Nature Conservancy. The activities involve grouper and marine fish aquaculture as a management tool to reduce the threats to marine biodiversity in the park.

The Nature Conservancy in Indonesia

The Nature Conservancy mission is to preserve plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. The Conservancy and its members have been protecting more than 10 million acres in the United States of America and Canada. It has helped partner organizations to preserve millions of acres in Latin America, the Caribbean, the Pacific and Asia. While some Conservancy-acquired areas are sold to other conservation groups, both public and private, the Conservancy owns more than 1,600 preserves- the largest private system of nature sanctuaries in the world.

Drawn by Indonesia's biological richness and its being subject to imminent danger, the Conservancy opened an office in Jakarta in 1991. The initial goal was to protect Lore Lindu National Park (Sulawesi). In 1995, the Conservancy started the Komodo project. The aim of this project was to help local authorities to protect the marine area around the Komodo Islands.

Komodo National Park

The Komodo islands are located between the islands of Sumbawa and Flores in the Nusa Tenggara Timur Province of Indonesia. Komodo National Park encompasses three major islands (Komodo, Rinca and Padar) and numerous smaller islands, totaling

41,000 ha of land. The Park is famous as the habitat of the Komodo dragon *Varanus komodoensis*. Its 132,000 ha of marine waters are also one of the world's richest areas for coral and fish biodiversity (200+ species of reef-building corals, 1000+ species of fish). The number and variety of islands, together with a range of physical conditions, such as wind exposure, current and wave action, result in a high diversity of coastal and marine habitats, including coral reefs, rocky shores, sea grass beds, sandy bays and mangroves. There are presently some 2,300 inhabitants living within the Park, spread out over three settlements (Komodo, Rinca and Kerora). About 15,000 people live in villages surrounding the Park. Park inhabitants derive 90% of their livelihood from a pelagic lift net fishery that targets squid and small schooling pelagic fish.

The Park was established in 1980 and has a management unit of 88 staff. The Park was declared a Man and Biosphere Reserve and a World Heritage Site in 1986. At the request of the Indonesian Department of Forestry, the Conservancy co-operates with Komodo National Park's authority in management of the Park. The main threats to the Park's biodiversity are related to unsustainable and destructive uses of natural resources, including blast and cyanide fishing.

Conservation Management of the Marine Waters of Komodo National Park

Since the Conservancy established its Komodo Field Office in 1995, it has initiated and implemented a range of conservation activities:

- Law enforcement. The Komodo Field Office operates two speedboats that are used by Park authorities, the army and the police to conduct weekly patrols. The purpose of the patrols is to enforce the ban on blast and cyanide fishing. The implementation of the weekly patrols reduced blast fishing by 80%.
- Awareness and constituency building. The Conservancy produced and distributed a number of awareness materials: a comic book that explains the problem of blast fishing, leaflets, posters, and video documentaries. The awareness activities are tailored to the specific needs of the target groups (local communities, tourists who visit the area, local, regional and national decision-makers).
- Alternative livelihoods. The Komodo Field Office currently operates a pelagic fishery development project. This project is designed to steer fishermen away from unsustainable and destructive fishing practices by offering a livelihood in tuna and Spanish mackerel fishery. The planned fish culture project (described in more detail below) will also contribute to the generation of alternative livelihoods.
- Eco-tourism. The Conservancy considers the controlled development of eco-tourism as an opportunity for the Park to generate the funds for its management. The tourist industry can also boost the local economy. The Komodo Field Office facilitated a SCUBA dive instructor course that was attended by local tourist

guides. The Conservancy is maintaining close ties with local tourist entrepreneurs to promote an environmentally sound development of the tourist industry.

- Mooring buoy project. The Komodo Field Office installed and maintains 25 mooring buoys at diving and snorkeling sites in and around the Park. This helps minimize anchoring damage to the reefs caused by boats carrying divers.
- Monitoring and research. The Komodo Field Office conducts three monitoring programs: coral reef monitoring, fish monitoring, and resource use monitoring. Each of these monitoring programs provides feedback to the management and provides indicators for the success of the conservation program. The Komodo Field Office facilitates a PhD research project on coral reef rehabilitation.

Threats to Marine Biodiversity by the Live Reef Fish Trade

The live reef fish trade began in the Komodo area in the late 1990s, and groupers (*Epinephelus* spp. *Plectropomus* spp. mouse grouper *Cromileptes altivelis*) and Napoleon wrasse *Cheilinus undulatus* in and around the Park experience heavy exploitation, both by cyanide fishing and by hook-and-line fishing. The live reef fish trade threatens the Park's coral reef biodiversity through three related mechanisms (Erdmann & Pet-Soede 1996, Johannes & Riepen 1995, Pet and Pet-Soede 1999):

- Destructive fishing practices, causing chemical damage to coral reefs through the use of cyanide solutions to stun and capture target fish species, and physical damage through diving fishermen who break away corals around the hiding places of stunned target fish.
- High exploitation rates of wild populations of market-ready fish (adults and sub-adults), rendering it impossible for the wild stocks to recover. The most important target fish species are extremely vulnerable to overfishing, because these species tend to aggregate for spawning at certain sites during certain seasons. Once the commercial fishery locates a spawning aggregation site, the fishery can extract a significant portion of the adult stock with little effort.
- High exploitation rates of wild populations of fingerlings of target fish. The fingerlings are used to supply the developing grow-out fish culture industry. A fishery for grouper fingerlings has not developed yet in the Komodo area, but experience of other areas shows that there is a high probability that a fingerling fishery will develop in the future.

Fish Culture as a Means to Reduce Threats of Live Reef Fish Trade

In an effort to combat the threats posed by the live reef fish trade, the Conservancy developed a strategy consisting of the following components:

- Stimulating mariculture of high-quality food fish
- Identification, monitoring and management of spawning aggregation sites of the commercial fish species
- Reforming marine policies, marine tenure and legal frameworks including production of awareness and education materials

Developing a fish culture enterprise in the Komodo area can help to reduce threats posed by the live reef fish trade in two ways:

- Fish culture can contribute to the transformation of the live reef fish trade from unsustainable (wild-caught) to sustainable (culture based)
- A profitable fish culture sector in the Komodo area can generate an alternative livelihood for fishers who are presently using destructive fishing techniques

At the invitation of the Conservancy, AJ Aqua Intercon Pty. Ltd. carried out two surveys to assess the prospects for aquaculture in the Komodo area (Ogburn & Ogburn 1996). The consultants concluded that the prospects for aquaculture development in the Komodo area are excellent. Some of the advantages of the Komodo area from the perspective of mariculture are as follows:

- Good water quality, because of the dry climate (no land run-off). Furthermore, because the Komodo area is a sea strait between two major islands (Sumbawa and Flores) there is a high flow-through of clean oceanic water. There is no history of 'red tide' algae blooms in the Komodo area
- The Komodo area is not situated in a typhoon area
- Cheap trash fish suitable for fish feed is available throughout the year
- The area has already been opened to the live reef fish trade, hence marketing of a live product should be relatively easy
- The local communities are already familiar with fish cage technology
- There are numerous islands and shallow bays in the area, which offer suitable sites for mariculture activities (fish cages, hatchery enterprise)
- Commercial species that are suitable for mariculture are native in the area, therefore broodstock for mariculture can be acquired locally and there is no risk for unintentional introduction of foreign species into the area

One of the constraints is the availability of fingerlings for a fish grow-out enterprise. Chinese Taipei is the only economy that produces grouper fingerlings; mainly estuary grouper *Epinephelus coioides* and Malabar grouper *E. malabaricus* (World Bank 1999). Though several research institutes in Indonesia successfully reproduced a variety of grouper species in captivity (Balai Budidaya Laut Lampung 1998, Sugama et al. 1999), hatchery-reared grouper fingerlings are not yet widely available. Capture from the wild remains the main source of grouper fingerlings for grow-out.

The Nature Conservancy intends to implement a hatchery-based grouper culture project in the Komodo area. The project will establish a multi-species hatchery that will provide the fingerlings for grow-out. For this purpose, the Komodo Field Office has been collecting broodstock from the wild since 1997. The five species that will be cultured include three grouper species (for which commercial scale hatchery techniques are not yet established in Indonesia), and two other species (for which fingerling production techniques are already established). The grouper species (estuary grouper *Epinephelus coioides*, Malabar grouper *E. malabaricus*, mouse grouper *Cromileptes altivelis*), have good marketing prospects, whereas fingerling production of the other two species (mangrove jack *Lutjanus argentimaculatus* and seabass *Lates calcarifer*) will ensure continuity of the hatchery enterprise. The fingerlings will be distributed to local communities for grow-out in fish cages. The hatchery enterprise may also play a role in the marketing of the end product.

The first phase of the project (three months ending August 1999) is the development of a business plan. The business plan will describe under what conditions a grouper culture project is economically viable, and it will function as a guideline for the project design. Next, a pilot hatchery will be established to obtain experience with hatchery techniques (one year). In the final phase (at least one year), local villagers will be involved in the grow-out of the fingerlings, and the hatchery will be brought to commercial scale. At the end of the project, the hatchery enterprise will be transferred to a local entity, probably a cooperative of fishers, or a local fish trader. The Conservancy's main partners in the Komodo fish culture project are the Queensland Department of Primary Industries and the Gondol Research Station for Coastal Fisheries.

References

- Balai Budidaya Laut Lampung 1998.** Pembenihan kerapu macan (*Epinephelus fuscoguttatus*). Report of Balai Budidaya Laut Lampung. 85 p.
- Erdmann, M.V. & Pet-Soede, L. 1996.** The live reef food fish trade in Eastern Indonesia. Naga, The ICLARM Quarterly. January 1996. p. 4-8
- Johannes R.E. & M. Riepen 1995.** Environmental, economic and social implications of the live reef fish trade in Asia and the Western Pacific. Report to The Nature Conservancy and the South Pacific Forum Fisheries Agency. 82 p.
- Ogburn D.M. & N.J. Ogburn 1996.** Prospects for development of aquaculture in Northwest Flores and Komodo National Park and their surrounding areas, Nusa Tenggara Timur, Indonesia. Report to The Nature Conservancy Asia/Pacific Coastal and Marine Program. 28 p.
- Pet J.S. & L. Pet-Soede 1999.** A note on cyanide fishing in Indonesia. Live Reef Fish Information Bulletin 5: P. 21-22.
- Sugama K. Trijoko, Wardoyo, J.H. Hutapea, H. Matsuda & S. Kumagai 1999.** Natural spawning and larval rearing of barramundi cod, *Cromileptes altivelis*, in tanks. In: The Proceedings of APEC/NACA Cooperative Grouper Aquaculture Workshop, Hat Yai, Thailand, 7-9 April 1999.
- World Bank 1999.** Opportunities and constraints of grouper aquaculture in Asia. Report to the World Bank.

5.16 Nutritional Requirements of Grouper (*Epinephelus* spp.)

Mali Boonyaratpalin

Department of Fisheries
Bangkok, Thailand

Abstract

This paper covered information on the nutritional requirements for various grouper species. It also provides information on the requirements of vitamin, mineral and also the essential fatty acid. Feed and feeding are also being described.

Introduction

Grouper is the most popular maricultured fish in Southeast Asia and live grouper command a high price in Hong Kong, China. The red grouper, *Epinephelus akaara* is a preferred species as it symbolizes good fortune [in Hong Kong] and is often served at wedding dinners (Tseng & Ho, 1988). *E. akaara* is a slow growing grouper in comparison to *E. tauvina*, which is widely cultivated in Asian countries.

Groupers are sluggish fish. In their natural habitat they normally rest in rocky areas or at the bottom of cages when they are cultured. In a culture environment, suspended material such as used automobile tyres increase the resting surface area. The sluggish nature of the grouper helps reduce feeding frequency.

Groupers can withstand salinity ranging from 15 to 45 ppt. They can also withstand washing with freshwater for longer than fifteen minutes. The optimum temperature range is 22-28°C. When the temperature is below 15°C, the fish do not eat. The grouper is euryphagous, and prefers crustaceans and live food (Randall, 1965).

Longly and Hildebrand (1941) reported that *E. mario* feed indifferently day or night. *E. akaara* favours feeding just before sunset. Cultured red groupers exhibit special feeding behaviour. The fish can be trained to know when they will be fed. When they sense the sounds of chopping of trash fish or knocking of a wood plank, they gather at the cage edge. As the fish have a suspicious nature, they keep a look out for food but do not move. However, if one of them approaches the food, all will immediately snatch at it, sometimes injuring themselves in the process. Groupers usually eat one to three pieces of minced trash fish and then swim away. They do not eat food which falls to the net bottom. Due to this special feeding behaviour, groupers are generally mix-cultured with sea breams who act as scavengers and stimulate groupers to feed.

Table 1: Composition of formulated diet for grouper *E. tauvina* and seabass *Lates calcarifer* (Kanazawa 1984)

Ingredient	Percent
Fish meal	34
Meat and bone meal	10
Soybean meal	15
Groundnut meal, expellar	10
Ricebran, solvent extracted	10
Leaf meal	5
Tapioca	8
Vitamin and mineral mixture	1
Soybean or corn oil	4
Squid or pollack liver oil	3
BHT	0.02
Ethoxyquin	0.02

E. tauvina is a hermaphrodite (gynandrous) fish. Males are generally absent in the smaller length-classes. The sexually mature males are more than 740 mm in standard length at the age of nine years or more. Chen et al. (1977) reported that three year old females could be transformed into males by an oral application of methyltestosterone.

Groupers are potentially important aquaculture species since they are fast growing, accept dry pellet feed, have high feed efficiency and have a very high economic value. A success of larval rearing and a success of spawning in captivity constitute crucial factors. Trash fish is the most common feed used in the cage culture of grouper. A high price, shortage of supply, variable quality, and poor feed conversion rate indicate that trash fish is neither nutritionally adequate nor economically suitable for grouper. It is important to develop a balanced and cheap diet for this fish.

Nutrient Requirements

As groupers are carnivorous, their dietary protein requirements are high. Teng et al. (1977) reported that a maximum weight gain by *E. tauvina* was achieved at a dietary protein concentration of 50%. These researchers suggested that a dietary protein concentration of 40% was the most economical.

Sukhawongs et al. (1978) conducted experiments on two sizes of *E. tauvina* (20 g to 30 g, and 60 g to 70 g). They were fed diets with 30%, 40%, 45%, or 50% levels of protein. The best weight gain was observed at 50% dietary protein level. An optimum protein level of 45% for *E. tauvina* was also reported by E1-Dakour and George (1982). Teng (1979) found that 40% dietary protein was optimum for *E. salmonoides* (formerly cited as *E. tauvina*).

Wongsomnuk et al. (1978) observed a comparable trend for a higher protein requirement by smaller sized fish. Teng et al. (1978) determined the optimum dietary protein level for 65 g to 170 g estuarine grouper (*E. salmonoides*) fed to satiation with moist diets having sun-dried tuna muscle as the protein source to be 40% on a dry matter basis. The dietary energy of the 40% protein diet was 3,302 kcal/kg on a dry weight basis calculated on an energy value of 3.9, 8.0 and 1.6 kcal/g for protein, lipid and carbohydrate respectively giving a P:E ratio of 121 mg protein/kcal. The optimum diet had a lipid content of 13.5% on a dry weight basis. Chen and Tsai (1994) reported that the dietary protein level that yielded maximum growth in *E. malabaricus* was 47.8% based on a broken-line model estimation of the weight gain results. Shiau and Lan (1996) fed diets with two dietary protein levels (50% and 44%) and four energy levels at each protein level (305, 340, 375, 410 kcal of GE per 100 g diet). The results show that when the energy level of a diet is maintained at 340-375 kcal per 100 g, the dietary protein level for juvenile grouper can be lowered from 50% to 44%.

Tucker (1991) reported that the optimum protein energy ratio for *E. tauvina* weighing 60-130 g was about 94 mg/kcal GE, and 142 and 162 mg/kcal DE for *E. malabaricus* and *E. striatus*, respectively. The data from Shiau and Lan (1996) suggested that the optimum P:E ratio for *E. malabaricus* was 117 mg to 129 mg/kcal GE. New (1987) reported that the optimum concentration of lipid in the grouper diet was about 14%.

Vitamin and Mineral Requirements

The ascorbic acid requirement has been studied in *E. tauvina* by Boonyaratpalin et al. (1993). A study was conducted to determine the effects of vitamin C in the form of L-ascorbyl 2-phosphate-Mg on feeding rate, growth, feed efficiency, % hydroxyproline of protein, survival, and deficiency signs in juvenile *E. malabaricus*. A practical diet was supplemented with 0 mg, 30 mg, 60 mg and 100 mg of L-ascorbyl 2-phosphate-Mg per kg dry diet. The experiment was carried out for sixteen weeks in aquaria. The feeding rate, growth, feed efficiency, % hydroxyproline of protein and survival of fish fed with the diet without supplementary L-ascorbyl 2-phosphate-Mg were significantly lower ($P < 0.05$) compared with other treatments. Fish fed a diet without supplementary L-ascorbyl 2-phosphate-Mg showed deficiency signs. The signs of vitamin C deficiency included loss of appetite, short snout, erosion of the opercula and fins, haemorrhaging eyes and fins, exophthalmia, swollen abdomen, abnormal skull, falling pharyngobranchials, severe emaciation, scoliosis and lordosis. The minimum level of L-ascorbyl 2-phosphate-Mg required for normal growth was 30 mg/kg dry diet. Histological observation of the gills of scorbutic fish showed hyperplasia of epithelial cells of primary and secondary lamellae, fusion of secondary lamellae, gill cartilage distortion and detachment of the epithelium from the basal membrane of the secondary lamellae. By electron microscopy, degeneration of chloride cells, mucous cells and epithelium cells as well as hyperplasia and edema of epithelium cells were observed. (Phromkunthong et al, 1993)

E. malabaricus spawners were reared for nine months using three feed formulae. Formula 1(control) was fresh *Caranx*, Formula 2 was fresh *Caranx* supplemented with vitamin E at 200 mg/kg feed and Formula 3 was fresh *Caranx* supplemented with 400 mg vitamin E per kilogram of feed. After the study period, Formula 3 feed resulted in the highest percentage of eggs collected and was, therefore, considered to be the optimum feed for grouper propagation (Chulawittayanukul, 1986).

Essential Fatty acid

Ruangpanich and Boonliptanond (1993) determined the essential fatty acid requirement of grouper. Larvae between one and fifteen days of age fed essential fatty acids (n3 HUFA)-enriched rotifers showed no significant difference in survival compared to rotifers maintained in *Chlorella* as food source. This gives an indication that larvae were not deficient in essential fatty acids when given *Chlorella* rotifers. Therefore, rotifers should be maintained in *Chlorella* media for six hours before feeding fish larvae. This can increase the levels of essential fatty acids in rotifers up to 12%, which is considered optimum for the feeding of fish larvae (Watanabe, 1983, Ruangpanich and Boonliptanond, 1993).

When fifteen day-old larvae were fed brine shrimp without fatty acid supplementation, the fish began to show general body weakness and mortality starting at twenty-one days of age resulting in total mortality by thirty days. When larvae were fed brine shrimp enriched with fish oil at 25 or 50 ml/m³ of the rearing water, they showed normal growth. Some developed into juveniles at the age of thirty-seven days and all become juveniles by age fifty days. The survival rate for these two treatments was 50.5% and 56% respectively.

Pechmanee and Assavaaree (1993) reported that n-3 HUFA content of rotifers fed fish oil emulsified with raw egg yolk and a commercial emulsified oil was higher than that of rotifer fed *Chlorella* sp. After three to six hours of feeding, the n-3 HUFA content of rotifers fed fish oil, emulsified with raw egg yolk was 17.9% and 13.8% of the total lipid respectively, whereas the n-3 HUFA content in rotifers fed a commercial emulsified oil was 14.6% and 19.3% of total lipid respectively. It is suggested that rotifer should be enriched with n-3 HUFA before feeding grouper larvae after six days of age.

Feed and Feeding

The traditional grouper feed in floating net cages is trash fish, similar to that for seabass. Commercial, slow-sinking, extruded feed is available in some Asian countries. This commercial feed is believed to contain not less than 43% crude protein, not less than 6% fat, not more than 16% ash, 3% fiber and 12% moisture. A practical feed formu-

lation based on availability of local feed ingredients as recommended by Kanazawa (1984) and Tacon et al. (1989) is presented in Tables 1 and 2, respectively.

Chua and Teng, (1978) conducted a three month study on the effect of feeding frequency on the growth of young *E. tauvina* being cultured in floating net cages. Seven feedings [to satiation] frequencies were studied: once every day, every two days, every three days, every four days, every five days, twice a day, and three times a day.

Optimal growth, good feed conversion ratio, and higher survival rates were observed in feeding to satiation once every two days. Weight gain was substantially lower in treatments involving once every three, four and five days. No enhancement in growth was observed when the frequency was increased to two or three feedings daily. The fact that feed conversion ratios were similar in fish fed to satiation with one feeding in five, four and two days suggests that feed intake is an important growth factor. Total feed intake was significant in fish fed once every two days. The intake of food was found to be closely related to the amount of food remaining in the stomach, with the intake being maximal when the stomach was empty. The food deprivation time of grouper is about thirty-six hours, at which time over 95% of the food is digested at a water temperature of 30±1 °C. Hence, feeding the fish once every two days greatly enhanced intake and use of feed. Dawes (1930), Moore (1941) and Hickling (1962) found that if a second meal was taken too soon after the first, or if fish accept too much feed, digestion was less efficient.

Table 2: Composition of formulated test diets for grouper (Tacon et al. 1989)

Ingredient	Formulation	
	1	2
Brown fish meal	75	66
Shrimp head meal	-	5
Squid liver powder	-	5
Suehiro UGF	-	5
Wheat middlings	8.6	3
Wheat flour	10	10
Zeolite	0.75	0.75
Fish oil	4.2	3.8
Soy lecithin	0.75	0.75
Choline chloride (50%)	0.40	0.40
Vitamin premix AGJT/F1*	0.33	0.33
Mineral premix AGJT/F1**	0.037	0.037
Total	100.067	100.067

*Vitamin premix AGJT/F1 supplies per kilogram of dry diet: Vitamin A 4000 IU, Vitamin D3 2000 IU, Vitamin E 200 mg, Vitamin K₃ 8 mg, Thiamine 32 mg, Riboflavin 40 mg, Pyridoxine 32 mg, Pantothenic acid 120 mg, Nicotinic acid 160 mg, Biotin 0.4 mg, Folic acid 8 mg, Vitamin B₁₂ 0.04 mg, Inositol 300 mg, Vitamin C 800 mg.

**Mineral premix AGJT/F1 supplies per kilogram of dry diet: Iron 30 mg, Zinc 50 mg, Manganese 25 mg, Copper 3 mg, Cobalt 0.5 mg, Iodine 3 mg, Trivalent chromium 0.25 mg, Selenium 0.10 mg.

The effect of food ratio on the growth and yield of the grouper raised in floating net-cages was investigated. A ration provided at 5% of body weight yielded the best body weight, a uniform size, a relatively better survival rate, and the highest feed efficiency. Rations provided at 1.41% and 5.75% of body weight were considered suitable for maintenance, and best weight gain respectively whereas ration provided at 9% was considered to be representing maximum feed intake. The fish were more uniform in size when fed at 5% to 8% of body weight. Although the yield increased with an increase in ration rate, the percentage increase between net yield of fish on 5% ration over 2% ration was 59.6% while the difference between net yield on rations above 5% was 26.8% to 33.6%. For economic production, the ration should be approximately 5% of body weight supplied every two days (Chua and Teng, 1982).

It appears that the nutrient requirement of grouper is similar to that of seabass and that practical seabass feed is expected to work equally well for grouper. Frequency is a major difference between these two species of fish.

References

- Boonyaratpalin, M. J. Wannagowat. and C. Borisut. 1993.** L-ascorbyl 1-2 phosphate-Mg as a dietary vitamin C source for grouper. Presented at the seminar on fisheries 1993, Department of Fisheries, 16-17 September 1993.
- Chen, F. Y. M. Chow. T. M. Chao. and R. Lim. 1977.** Artificial spawning and larval rearing of the grouper, *Epinephelus tauvina* (Forsskal) in Singapore. Singapore J. Pri. Ind. 5 (1) 1.21.
- Chen, H. Y. and J.C. Tsai. 1994.** Optimal dietary protein level for the growth of juvenile grouper, *Epinephelus malabaricus*, fed semipurified diets. Aquaculture, 119: 265-271.
- Chua, T.E. and S.K. Teng. 1978.** Effects of feeding frequency on the growth of young estuary grouper, *Epinephelus tauvina* (Forsskal), cultured in floating cages. Aquaculture, 14:31-47.
- Chua, T.E. and S.K. Teng. 1982.** Effects of food ration on the growth, condition factor, food conversion efficiency and net yield of estuary grouper, *Epinephelus salmonoides* (Maxwell), cultured in floating net cages. Aquaculture, 27:273-283.
- Chulawittayanukul, P. 1986.** Effect of vitamin E on maturation and reproduction of grouper. Paper presented at the 3rd Brackish Water Fisheries Seminar, Brackish Water Division, Department of Fisheries. Bangkok, Thailand. 6 p.
- Dawes, B. 1930.** The absorption of fats and lipoids in plaice. J. Mar. Biol. Ass. U.K., 17:75 – 102.
- El - Dakour, S and K.A. George. 1982.** Growth of (*Epinephelus tauvina*) fed on different protein : energy ratios. Kuwait Inst. Sci. Res. Ann Res. Rep. pp 75-77.
- Hickling, C.F. 1962.** Fish culture. Faber and Faber, London. 295 pp.
- Kanazawa, A. 1984.** Feed formulation for penaeid shrimp, seabass, grouper and rabbitfish culture in Malaysia. pp 61-78. In: FAO, Malaysia Coastal Aquaculture Development Project. FI: DP MAL/77/008, Field Document 2.
- Longly, W.H. and S.F. Hildebrand. 1941.** Systematic Catalogue.
- Moore, W.G. 1941.** Studies on the habits of fishes. Ecol. 22: 91-96.
- New, M.B. 1987.** Feed and feeding of fish and shrimp: A manual on the preparation and presentation of compound feeds for shrimp and fish in aquaculture. United Nations Development Program, Food and Agriculture Organization of the United Nations, Rome, pp 111.
- Pechamane, T. and M. Assavaaree. 1993.** Nutritional value of rotifer, *Branchionus plicatilis*, fed with emulsified oils rich in n3HUFA. The Proceedings of Grouper Culture, Songkhla, Thailand p. 63-67.
- Phromkunthong, W.M. Boonyaratpalin and W. Verakunpiriya. 1993.** Histopathology of the gills of ascorbic acid deficient grouper *Epinephelus malabaricus*. Fish Pathol, 28(4): 151-159.
- Randall, J.E. 1965.** Food habits of reef fishes of the West Indies. Stud. Trop. Oceanog., 5: 665 -847.

- Ruangpanich N. and P. Boonliptanond. 1993.** Some factors affecting the growth and survival of grouper larvae (*Epinephelus malabaricus*). National Institute of Coastal Aquaculture, Department of Fisheries, Thailand Technical Paper No. 20.
- Shiau, S.Y. and C.W. Lan. 1996.** Optimum dietary protein level and protein to energy ratio for growth of grouper (*Epinephelus malabaricus*) Aquaculture 145: 259-266.
- Sukhawongs, S. N. Tanakumchup. and S. Chungyampin. 1978.** Feeding experiment on artificial diet for greasy grouper, *Epinephelus tauvina* in nylon cages. Annual Report of Songkhla Fisheries Station, Department of Fisheries. pp 103-117.
- Tacon, A.G.J. et al. 1989.** The food and feeding of seabass (*Lates calcarifer*), grouper (*Epinephelus tauvina*) and rabbitfish (*Siganus canaliculatus*) in floating net cages at the National Sea Farming Development Center, Lampung, Indonesia. Sea Farming Development Project, FAO. INS/81/008/Technical Paper/13.
- Teng, S.K. 1979.** Studies on the culture of the estuary grouper, *Epinephelus salmoides*, Maxwell (Pisces: Serranidae) in floating net cages. P 61. *In: Grouper Abstracts, Brackish water Aquaculture Information System*, Compiled by A. Divina and V. Zamora et al. SEAFDEC, Philippines, 1987.
- Teng, S. K. T.B. Chua and P.E. Lim. 1977.** Preliminary observation on the dietary protein requirement of estuary grouper, *Epinephelus tauvina* (Forsskal) cultured in floating net cages. P 60. *In: Grouper Abstracts, Brackish water Aquaculture Information System*. Compiled by M.A.V. Divina and V. Zamora et al. SEAFDEC, Philippines, 1987.
- Teng, S. K. T.B. Chua and P.E. Lim. 1978.** Preliminary observation on the dietary protein requirement of estuary grouper, *Epinephelus tauvina* (Forsskal) cultured in floating net cages, Aquaculture 15 (3) 257-272.
- Tseng, W.Y and S.K. Ho. 1988.** Grouper culture, a practical manual. Chien Cheng Publisher, Kaohsiung. R.O.C. 134 pp.
- Tucker, J.W. Jr. 1991.** Marine fish nutrition. *In: G.L. Allan and W. Dall (Eds.) Proc. Aquaculture Nutrition workshop, Salamander Bay, 15-17 April 1991, NSW fisheries, brackish water Fish Culture Research Station, Salamander Bay, Australia.*
- Watanabe, T. T. Arakawa, C. Kitajima and S. Fujita. 1983.** Improvement of dietary value of live foods for fish larvae by feeding them on n3 highly unsaturated fatty acid and fat soluble vitamin. Bulletin of the Japanese Society of Scientific Fisheries, 49(3): 471-479.
- Wongsomnuk, S. P. Parnichsuka and Y. Danayadol. 1978.** Experiment on nursing of grouper, *Epinephelus tauvina* (Forsskal) with various mixed feeds. Pp. 79-102. *In: Annual Report of Songkhla Fisheries Station, Department of Fisheries.*

5.17 Grouper Aquaculture in Chinese Taipei

Huei Meei Su

Tungkang Marine Laboratory

Taiwan Fisheries Research Institute, Chinese Taipei

Abstract

This article presents various grouper species that have been cultured in Chinese Taipei. It also provides some production figures as well as the costs of the eggs and fingerlings for various groupers. The grouper diseases that experienced in Chinese Taipei are also described.

- Develop the indoor larviculture systems for grouper
- The status of the grouper farming industry in Chinese Taipei

***Epinephelus lanceolatus*, giant grouper**

- Spawners: in 1998, seven year old, 70 male and 110 female produced 260 kg (360,000,000 eggs) during four months; 300,000 3 cm juveniles survived (0.08%); 70,000 3 cm to 7 cm juveniles survived (23%)
- Grow-out was very fast from 3 cm to 600 g (about 6 months), then till 3,600 g at a growth rate of 400 g per month, afterward at a rate of 600 g per month

Table 1: Milestones in grouper larviculture in Chinese Taipei

	Milestone	Date
1	<i>Epinephelus tauvina?</i> TFRI TML indoor 54 th 5 cm 238	June 1982
2	<i>Epinephelus malabaricus</i> Mr. Lin indoor 30 th 3 cm 11,430 and 15,070	May-July 1984
	<i>E. malabaricus</i> TFRI Penghu branch 93 th 6-12 cm 10,450 (14% from egg)	Apr.-Aug. 1985
3	<i>E. malabaricus</i> & <i>coioides</i> Mr. Lin outdoor 2 cm 150,000 (18% from fry)	March 1987
4	Cultured spawners <i>E. malabaricus</i> & <i>coioides</i> 3 cm 1,000,000 4 species	1987
5	Cultured spawners <i>Epinephelus lanceolatus</i> 3 cm 20,000 7cm 5,000	July 1996
	<i>E. lanceolatus</i> 360,000,000 eggs 3cm 300,000, 7 cm 70,000	July-Oct. 1998
6	Cultured spawners <i>Epinephelus fuscoguttatus</i> 3 cm 100,000	1998

Table 2: Growth of three species of grouper

	egg→3 cm	7 cm→600g	1 kg→2 kg
<i>E. malabaricus</i>	35 days	12 months	
<i>E. lanceolatus</i>	35 days	6 months	3 months
<i>E. coioides</i>	35 days	12-15 months	1 year
<i>Plectropomus leopardus</i>		2.5 years	

Table 3: Grouper species cultured in Chinese Taipei

Index	Species Name	English Name	Fry Source
	<i>Cheilimus undulatus</i>	Giant wrasse	Wild
	<i>Chromileptes altivelis</i>	Mouse grouper	Set up
	<i>Epinephelus akaara</i>	Red grouper	Wild, Set up
	<i>E. awoara</i>	Banded grouper	Wild, Set up
1	<i>E. coioides</i>	Red-spotted grouper	Established
	<i>E. fario</i>	Black-saddled grouper	Set up
5	<i>E. fuscoguttatus</i>	Tiger grouper	Established
3	<i>E. lanceolatus</i>	Giant grouper	Established
2	<i>E. malabaricus</i>	Malabar grouper	Established
	<i>E. quoyanus</i>	Long-finned rockcod	Wild, Set up
4	<i>E. tauvina</i>	Estuary grouper	Established
	<i>E. trimaculatus(fario?)</i>	Brown marbled grouper	Set up
	<i>Plectropomus leopardus</i>	Coral trout	Set up

Production of Grouper Fry in Chinese Taipei

- Fertilized egg production
 - a) About ten main broodstock farmers
 - b) Estimated annual fertilized egg production is 20 billion
- Fry production systems
 - a) Outdoor system >200-ton pond
 - b) Indoor system 30 to 50-ton pond
 - c) Estimated total annual fry production
 - d) 20,000,000 to 30,000,000 fry per year (1995-1997)
 - e) Survival rate 0-30%, average survival rate 0.1 to 0.15%
- Reasons for success in mass production of grouper fry
 - a) Aggregated hatchery
 - b) Sound R&D infrastructure
 - c) Wide use of formulated feeds
 - d) Advance in fry production system

- e) Well experienced hatchery operators
- f) Success in production of fertilized eggs
- g) High efficiency in live food production system

- Problems

- a) Instability of production
- b) Virus infection (serious after 1994)

- Prospects

- a) Vast Chinese market
- b) Enhancement of seed quality
- c) Enhancement in disease control
- d) Enhancement in international research and production cooperation

Table 4: Price of *E. coiodes* Eggs and Fry (\$US)

Year	Egg	2 to 3 cm	7 cm
1986		1.0 to 1.3	2 to 2.3
1988			
1989		0.7 to 1.1	
1990		0.9 to 1.0	1.1 to 2.7
1991	0.0033	1 to 1.46	3.8 to 6.0
1992	0.0033	1.0 to 1.5	
1993	0.0033	0.9 to 1.1	2.8 to 3.3
1994	0.0001 to 0.0033	0.4 to 1.0	1.2 to 3.1
1995	0.0003 to 0.0014	0.27 to 0.9	0.8 to 2.9
1996	0.0002 to 0.0014		
1997	0.0001 to 0.0014	0.1 to 0.33	
1998	0.0001 to 0.0007		1.1
1999	0.0001 to 0.0007	0.1 to 0.33	0.8
1998*	0.396	2.3	7

**E. lanceolatus*

Disease

Protozoa: *Amyloodinium ocellatus*, *Cryptocaryon irritans*, *Trichodina* sp.

Parasite: *Dactylogyrus* sp.

Bacteria: Not specified

Virus: Nodavirus NNV (20 nm to 25 nm), Iridovirus-like (125 nm to 150 nm), Rhabdovirus-like (75 nm to 95nm x 106 nm-119 nm)

Symptoms of NNV infection: the fry swim in a whirling or a corkscrew pattern and die quickly (10 to 14 days). The death rate was 80% to 100% (1994).

Symptom of Iridovirus-like infection: Fry and juvenile (2cm to 4cm) had a mortality rate above 60%, but 5% to 30% in fish >25 cm. The infection lasted for one to two months. Affected fish displayed blackening of the body, breathing difficulty and reduced feed intake (1994).

Table 5: Production of *E.coiodes* spawners, fry and juveniles

Year	Spawners	2 to 3 cm	7 cm
1988		1,000,000	
1989		2,000,000	
1990		3,000,000	
1991	2,000	6,000,000	4,000,000
1992	4,000	7,000,000	5,000,000
1993	5,000	8,000,000	6,000,000
1994	10,000	12,000,000	6,000,000
1995	20,000	20,000,000	8,000,000
1996		20,000,000	
1997		20,000,000	
1998			
1998*	70-100	200,000	60,000

**E. lanceolatus*

5.18 Surface-death Occurrence in the Larval Stage of *Epinephelus akaara*

Kosaku Yamaoka

*Usa Marine Biological Institute, Kochi University
194 Inoshiri, Usa, Tosa, Kochi 781-1164, Japan*

Abstract

*We conducted three experiments on environmental changes to identify the factors causing mass surface mortality of the red spotted grouper (*Epinephelus akaara*) at the pre-larval stage. The first experiment was on light intensity. It showed that a light source attracted the larvae. The maximum number of dead fish was at 2,000 lx. The second experiment involved placing an oil film on the water surface. It showed that the oil film prevented mass surface mortality. The third experiment was on the water current in the experimental tank. It showed that the presence of water current decreased the number of dead fish. These results suggest that surface tension is a key environmental factor in the occurrence of surface mortality. The mucus on the body surface of pre-larvae functions as a glue when larvae are attracted to the surface by light. The oil film deprives the water of surface tension and seems to prevent mass surface mortality.*

5.19 Trends in Major Asian Markets for Live Grouper

Sudari Pawiro

INFOFISH, Kuala Lumpur, Malaysia

Abstract

This paper describes the market trends for live grouper in Asian markets, with specifically cover markets like China, Singapore, Hong Kong and Chinese Taipei. It also covers areas such as trade issues and eco-labelling.

Trends in Major Markets

Hong Kong and the southern part of China are considered the main markets for live grouper. As a large part of the grouper supply in China comes from Hong Kong, the latter is the main player in the live grouper trade. Other smaller markets include Chinese Taipei and Singapore. Chinese Taipei is one of the main producers of cultured grouper in the region, thus, local consumption is met by domestic production. The Singapore market consumes a large quantity of live marine finfish, but only a small proportion are grouper while the rest are lower-priced species. As Hong Kong is the main determining market for live grouper, much of the discussion in this paper refers to this market.

Hong Kong

Hong Kong Agriculture and Fisheries Department (AFD) estimated the consumption of live marine fish in 1997 at 27,735 mt, 23% of which was local in origin and the rest imported. No information on the consumption volume of live grouper in Hong Kong is available. However, based on the local production and import figures as well as industry sources, we can estimate that the live grouper consumption or market size in Hong Kong is around 5,000 to 6,000 tonnes per year.

The local production of grouper, mainly *Epinephelus areolatus* and *E. tauvina*, is from 1,000 to 11,000 tonnes. Import data is incomplete despite an initiative by the Hong Kong authorities to extend the HS code so that it includes live grouper (the initiative has been implemented since 1997). Import data is incomplete because live fish, which is brought in by Hong Kong-registered vessels, is not recorded in import statistics. Therefore, it is difficult to determine trends in the live grouper trade for the last five years. The following table shows the imports of live grouper and other marine finfish into Hong Kong from 1997-1998.

Based on the estimate that the volume of live marine fish brought in by Hong Kong vessels in 1997 was approximately 7% of the total imports, the estimated volume in 1998 is around 20,700 mt, a slight decrease compared to the volume in 1997. However, import of live grouper increased significantly from 5,715 mt in 1997 to 6,555 mt in 1998, a rise of 14.7% in terms of volume as well as value. The increase can be attributed mostly to the import of spotted grouper and other medium-priced grouper (mainly green grouper).

Imports of Live Grouper and Other Marine Finfish into Hong Kong, 1997-1998 (Q=tonnes, V=HK\$1000)				
Species	1997		1998	
	Q	V	Q	V
High-finned grouper	14.40	3 590	12.00	2 729
Spotted grouper	840.20	93 159	1 136.90	119 394
Other grouper	4 860.60	255 816	5 406.30	282 260
Humphead wrasse	1.80	252	4.30	626
Other wrasse and parrotfish	10.00	870	10.60	844
Sub-total of high-value marine fish (coral reef fish)	5 727.00	353 687	6 558.10	405 853
Snook and basses	1 346.10	27 338	2 001.20	37 739
Other marine finfish	12 928.20	646 873	10 807.00	463 896
Total Marine Finfish	20 001.30	1 027 898	19 366.30	907 488
AFD's estimate of overall imports of live marine finfish (including from local vessel carriers)	21 567.00	NA	10 976*	NA

*Source: AFD, 1998. Note: * Data for the first semester of 1998.*

According to industry sources, the increased import of live grouper in 1998 did not represent greater consumption of live seafood. Hong Kong is affected by the current regional economic turmoil; live seafood restaurant sales dropped significantly (industry sources say by 40%). This estimate is supported by official statistics, restaurant sales (where live seafood is served) dropped by 10.3% in terms of value or 12.2% in terms of volume during the third quarter of 1998 compared to the same period of 1997.

Fewer consumers dining out and budget cuts for business entertainment are the main factors behind the negative trend. In addition, there were fewer tourists visiting Hong Kong, especially from Southeast Asian countries and Japan. During 1997, the number of tourist arrivals into Hong Kong decreased by 11%. During the period of January-July 1998, the number of tourists from Japan and Southeast Asian countries decreased by 44% and 34% respectively compared to the same period in 1997.

The import of live groupers has increased but domestic consumption has decreased. This can be explained by re-export to live seafood markets in Southern China, such as Shanghai, Guangzhou and Shenzhen. It is estimated that around 50% of the live seafood imported into Hong Kong is shipped to China.

Exports of Grouper to Hong Kong by Major Suppliers, 1998 (Q=tonnes, V=HK\$1000)				
Origin	Q	V	Average Price (HK/kg)	Main Species
Indonesia	1 341	114 321	85	main supplier of high-finned and spotted (coral trout) grouper 65% other grouper
Philippines	483	37,272	77	spotted grouper and other grouper
Malaysia	394	27,007	69	spotted grouper
Thailand	3,650	174,018	48	other grouper (low-value species)
Vietnam	102	8,713	85	spotted grouper
Australia	306	24,627	80	spotted grouper
Others	279	18,425	66	-
Total	6,555	404,383	62	
<i>Source: AFD, 1998.</i>				

The main suppliers of live grouper to Hong Kong are Indonesia, Philippines, Malaysia, Thailand, Vietnam and Australia. Thailand is the biggest supplier of low-priced grouper while Indonesia and Philippines export high-value species.

Declining demand also weakens the prices of most live seafood especially high-value species including grouper. The price trends of live seafood in Hong Kong from 1995 to 1998 are presented in graphs 1,2 and 3. They are based on the wholesale price data collected by the Agriculture and Fisheries Department, Hong Kong.

Graph 1 shows the price trends of wild (captured) and cultured grouper (red, brown-spotted and green grouper). Based on the graphs, the following trends can be identified:

- a) Prices of live grouper and other marine finfish continue to decline, particularly for high-value species. Prices of humphead wrasse decreased by 28.1%, green wrasse by 25.8% and green grouper by 19% during 1998 compared to 1997.
- b) The price spread between cultured and wild fish is wider for high-value species (red grouper), but lower for medium-priced species, (brown and green grouper).

China

In contrast to Hong Kong, the live seafood market in China is mainly supplied more from local sources (through aquaculture) with a smaller percentage from imports. The cultured species include both low-value carps, as well as more expensive live seafood such as silver pomfret, grouper, snapper, clams, abalone, shrimp and crab. Some high-value species such as grouper and lobster are imported.

There are two main sources of imported live seafood to China: direct imports from foreign suppliers and indirect imports through Hong Kong. The volume of direct imports into China (as recorded in official import statistics) is relatively lower than that of indirect imports through Hong Kong.

In 1997, direct imports of live finfish (including eel) into China were 116 tonnes valued at US\$ 3.7 million, which represents a decrease of 72% in volume and 60.4% in value compared to those in 1994. Imports of crustacea (mainly lobster, shrimp and crab) including fresh and chilled products, also decreased to 235 tonnes valued at US\$ 895.7 thousand in 1997 from 1,388 tonnes valued at US\$ 3.7 million in 1994, which represents a drop of 83% in quantity and 76% in value.

A large proportion of the live fish (mostly Malabar grouper and snapper) enters China through Hong Kong via legal and illegal channels. The legal channel consists of Hong Kong traders sending live fish to their trading partners in China by air, land and sea. To avoid the high import duty, Hong Kong traders usually set up joint ventures with state-owned companies or cooperatives who hold fish import quotas. According to official statistics, re-exports of live fish and shellfish from Hong Kong amounted to approximately 3,166 tonnes in 1997, mostly for the mainland market and a small amount to Chinese Taipei and Japan.

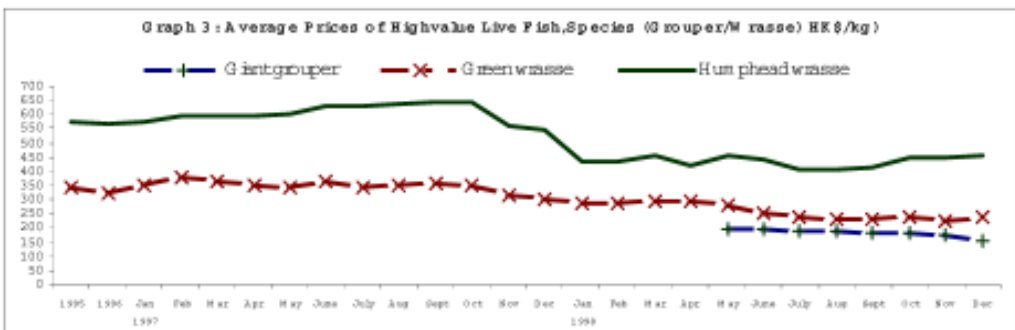
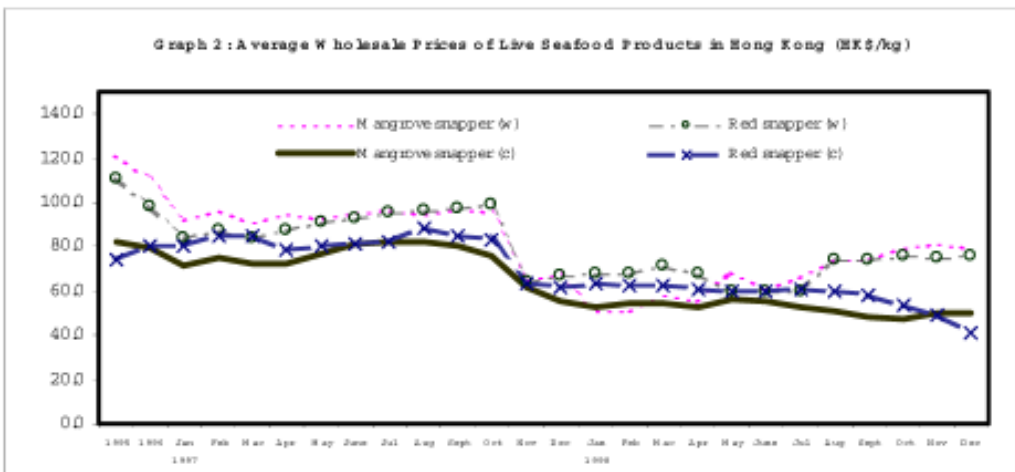
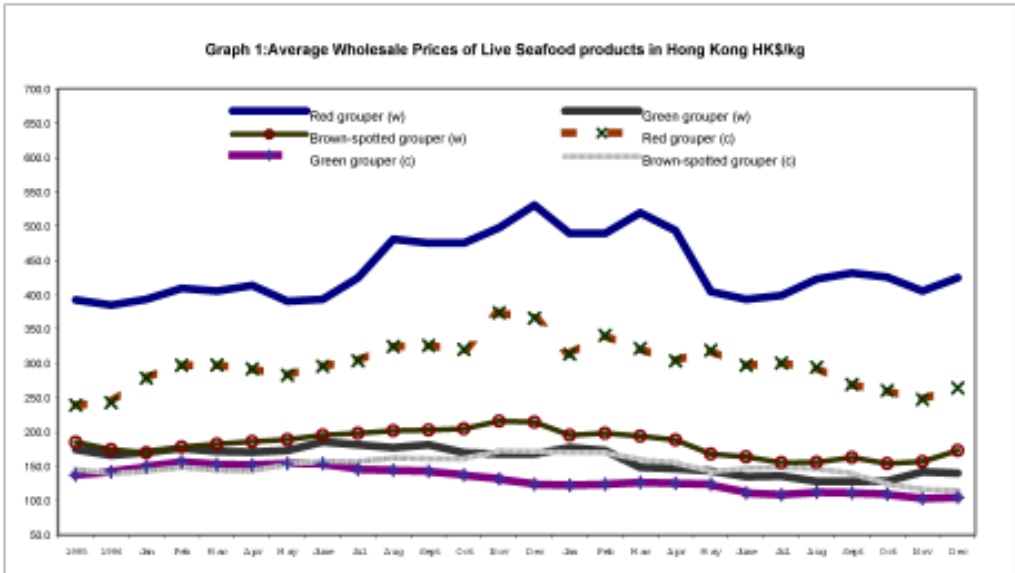
Imports of Live Seafood into China, 1994-1997 (Q=tonnes; V=US\$1000)								
	1994**		1995		1996		1997	
Species	Q	V	Q	V	Q	V	Q	V
Live fish (sub-total)	416	9,277	296.9	3,756.9	324.9	4,821.7	116.2	3,670.6
- Eels	61	224	148.2	490.7	122.3	424.6	9.6	12.1
- Carps	-	-	-	-	0.8	1.3	0.1	2.0
- Other fish	355	9 053	148.7	3,266.0	201.8	4,395.8	106.5	3,656.5

Source: China Bureau of Fisheries.
*Note: Included in other fish: ** FAO Year Book.*

The second channel is through unofficial means. The unofficial trade in fisheries product is prompted in part by the relatively high import duties China imposes on live seafood. Hong Kong traders ship seafood into China at minimal cost in a number of ways. Fish farmers with farms on the China-Hong Kong border are permitted to transport their product into China for a minimal levy. Cages belonging to Hong Kong fish farmers have another function as holding facilities for live fish from foreign suppliers. These fish are actually intended for the mainland market.

Live fish holding facilities at the wholesale level are similar to those in Hong Kong and are placed near the border. These operations are located near Shenzhen and Guangzhou but the seafood is also sent to other urban centres like Beijing and Shanghai duty-free as the fish are considered domestic products.

It was reported that at the beginning of the 1990s, Hong Kong consumed all live fish imported. By about 1992, China consumed 25% of Hong Kong's imported live seafood, which increased to 40% in 1995 (Johannes and Riepen, 1995). With the declining trend in the consumption of live seafood in Hong Kong, the amount of live fish



shipped to China is increasing. It is estimated that around 50% to 60% or around 15,000 tonnes of live seafood imported into Hong Kong is shipped to China annually.

Chinese Taipei

A variety of restaurants offer live fish. Grouper is an expensive fish and is typically sold in restaurants specialising in seafood. Salmon is used in Japanese restaurants to make sushi as well as in international and tourist hotels with fine dining facilities. Trout, another sought-after fish, is primarily sold in middle to upper-class restaurants specialising in seafood.

There are more than two thousand restaurants in this category throughout Chinese Taipei. Less expensive fish such as tilapia and seabass are more commonly served at smaller, buffet-style restaurants and street-side food stalls. During October to April the consumption of fish in restaurants and hotels increases as there are many holiday celebrations.

Special banquets or Ban Doe, account for 20% of shrimp consumption, and 30% of fresh finfish consumption. Although the Ban Doe is a traditional way of celebration known throughout Asia, it is particularly popular in Chinese Taipei. The number of participants at Ban Doe celebrations range from 1,200 to 5,000 people. As large volumes of live and fresh finfish, shellfish including shrimp are consumed, product is purchased directly from a seafood wholesaler.

Even though Chinese Taipei is a major market for live seafood, domestic aquaculture production can meet the demand. Import of live groupers for food is insignificant. In fact, it is a net exporter of live grouper. There is a significant amount of grouper fry being imported to supply the local aquaculture industry. In 1995, Chinese Taipei imported 21 mt of grouper fry but the import volume dropped to 9 mt in 1997.

Live Grouper Production and Trade (Q=tonnes, V=NT\$1000)				
		1995	1996	1997
Domestic production from aquaculture (mt)		2,104	1,882	2,529
Export	Q	67	229	249
	V	892	5,294	8,005
Import*	Q	20	9.3	17.5
	V	3,567	1,832	3,500

Source: Fisheries Yearbook 1994-1997.
*Note: * excluding groupers fry.*

Singapore

Import of live marine finfish for food has declined from 1,841 tonnes valued at S\$ 9.7 million in 1994 to around 1,200 tonnes valued at S\$ 6.5 million in 1998. Malaysia is the main supplier of live seafood consisting mostly of live seabass, snapper and a small amount of grouper.

There is no official record on the volume of live grouper imported into Singapore. Industry estimates are approximately 15% of live marine finfish, mostly consisting of black and brown grouper.

Imports of Live Marine Finfish to Singapore, excluding Fry & Ornamental Fish 1994-1998, (Q=tonnes; V=S\$1000)						
Origin		1994	1995	1996	1997	1998^{*)}
Malaysia	Q	1,773	1,504	1,426	1,225	1,210
	V	9,075	11,199	9,421	7,717	6,470
Others	Q	68	45	40	6	2
	V	649	383	408	58	22
Total	Q	1,841	1,549	1,466	1,244	1,212
	V	9,724	11,582	9,829	7,943	6,492
Estimates of imported groups ¹⁾	Q	270	232	--	187	182
	V	NA	NA	NA	NA	NA
<i>Note: *) based on 1st semester imports in 1998.</i>						
<i>1) based on industry information that around 15% of the imported live fish consists of groupers.</i>						
<i>Source: Singapore Trade Statistics.</i>						

It is worth noting that Singapore Trade Statistics do not include fish from Indonesian fishing vessels which bring in live marine finfish including live grouper. Therefore the market size for live grouper in Singapore is at least 400 to 500 tonnes annually including supply from local aquaculture.

The recent regional economic crisis has affected Singapore's economy. The number of tourists dropped, and restaurant sales declined as consumers spend less money for dining out. As a result, consumption of high-value live marine fish declined.

Market Access

Live fish trade usually faces higher import tariffs and more stringent control procedures compared to trade of fish in other forms. The import procedures focused mainly on the prevention of trading of illegal and endangered species and avoiding introduction of diseases. Regarding import duty, China applies very high tariffs of 45% plus 13% value-added tax (VAT) for live fish. Import duties in Chinese Taipei range from 20% to 40% depending on the live fish species.

Hong Kong and Singapore are free ports and there are no import tariffs, quotas or value-added taxes for any goods including live grouper. However, in Singapore, a 3% Goods and Services Tax (GST) is charged for all imported goods. Clearance procedures for imported consignments in both countries are very straightforward and follow international practices. In Singapore, all import declarations are submitted and processed electronically through an EDI system known as Trade Net. Malaysia also applies zero duty for imported live seafood products, and there are no quantitative restrictions on the import of fish and fishery products. However all imports of live fish (HS 0301.10-0301.99) into Malaysia must be accompanied by a Letter of Approval issued by or on behalf of the Director General of Fisheries.

Trade Issues

The live grouper trade issues are mostly environmental in nature. They include depleting resources due to trade expansion and illegal fishing methods. As a result, there has been strong support for developing a more sustainable grouper industry through aquaculture development. Despite great efforts to develop aquaculture in many countries, the industry still depends on wild resources.

A recent survey in major markets suggested that cultured species are becoming more acceptable to consumers and to importers as a result of declining purchasing power and supplies of wild caught fish. This is an encouraging trend, which serves as an incentive for aquaculture development.

Meanwhile, health and safety issues in the live grouper trade have been given less attention compared to processed seafood. This is probably because the markets for live grouper are limited to the region and there is not enough pressure from the importing countries regarding food safety. It would be a different case if the market for live groupers were the US or Europe.

It is noteworthy, however, that concerns over the detection of cyanide residue in grouper and ciguatera fish poisoning have been expressed. At the beginning of 1998 it was reported that 113 people in Hong Kong suffered from ciguatera poisoning, but there were no standard control enforcement procedures (Sadovy, 1998).

Eco-labelling as an Alternative

The live coral reef fish industry is a vulnerable industry, subject to unsustainable practices. High market demand threatens resources, as experienced by the industry when the market boomed during the early 1990s.

In recent years there have been extensive discussions on eco-labelling for fishery products as an alternative to achieve sustainable fisheries. This method is still at a premature

stage for fisheries products. However, its implementation is only a matter of time as there is increasing pressure from consumers and NGOs, especially in developed countries. Eco-labelling will succeed if consumers understand and support environmental concerns through their purchasing behaviour. Consumer responsiveness to environmental issues in Asian countries is limited compared to their counterparts in the US and Northern Europe.

Consumer education, especially in consuming and importing countries, is very important for promoting awareness of environmental issues and the use of purchasing power to encourage more sustainable fisheries practices. Experience shows that consumer power in importing countries has been very effective in enforcement of the eco-labelling scheme ‘dolphin safe’ labels for canned tuna. If this scenario were applied to live grouper and other coral reef fish, this would encourage the industry to act in a more sustainable way and discourage destructive fishing practices. We hope that in the future an eco-labelling scheme will be implemented for live coral reef fish and we will see glass tanks containing live grouper at restaurants in Hong Kong or Singapore with labels indicating ‘cyanide free’, ‘harvested from certified resources’ or ‘eco-friendly cultured grouper’.

Conclusions and Recommendations

The consumption of live seafood, especially high-value species such as grouper, is tied to the economic situation. Currently the economies of many countries in the region are affected by financial troubles. This negatively affected the consumption of high-value live fish and consumption is forecasted to fall for the next few years.

It is forecast that Asian markets will increasingly import low to medium-value live fish species and reduce the import of high-value live fish such as wrasse and high-finned grouper. Medium-priced species like malabar grouper, green grouper and red snapper (including those from culture) are becoming more acceptable to most restaurants, as they are cheaper and more readily available. This trend acts as an incentive for developing the aquaculture sector.

In 1998, according to industry sources, imports of cultured grouper into Hong Kong from the Philippines, Thailand and Chinese Taipei increased. Fish were sold at relatively lower prices. Given the decreased purchasing power in the region, it is a good time to promote cultured live grouper to slowly replace wild fish.

Eco-labelling is a medium-to-long-term option to achieve a more sustainable industry for the live grouper and other coral reef fish. Importing countries play a vital role in the promotion of eco-labelling by putting pressure on exporting countries to act in a more responsible way.

References

National Trade Statistics of Hong Kong, Chinese Taipei, China and Singapore.

Johannes, R.E. and Riepen, M. 1995. Environmental, Economic and Social Implications of the Live Reef Fish Trade in Asia and the Western Pacific.

Sadovy, Y. 1998. Ciguatera hits Hong Kong live fish trade. The Natural Conservancy, SPC Live Reef Fish Information Bulletin, April 1998.

5.20 Grouper Research at the Southeast Asian Fisheries Development Center Aquaculture Department

Clarissa L. Marte

*Southeast Asian Fisheries Development Center Aquaculture Department
Tigbauan, Iloilo, Philippines*

Abstract

This paper provides information on grouper research activities that have been carried out in SEAFDEC AQD. It covers various aspects such as broodstock management, seed production, nursery and grow-out culture techniques.

Introduction

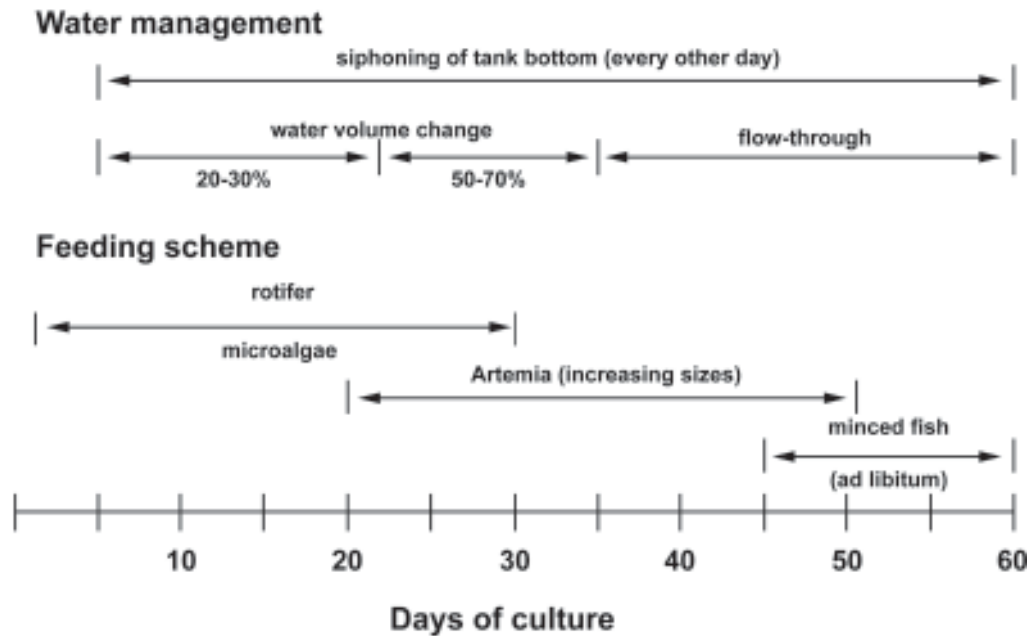
Research on breeding, seed production and culture of groupers at the Southeast Asian Fisheries Development Center Aquaculture Department (SEAFDEC AQD) was initiated following the recommendations of the 1987 Seminar-Workshop on Aquaculture Development in Southeast Asia (ADSEA), which prioritised the department's research and development activities. Initial activities focused on developing a captive broodstock, conducting a market survey of grouper species in the Philippines and in SE Asia (Kohno 1986, 1987, Kohno and Duray, 1989, Kohno et al., 1990), determining fry availability in reported fry grounds within Panay Island (where the department is located), and conducting a survey of culture practices in the Philippines (Kohno et al., 1988). Since the most common grouper species cultured in the Philippines and fished from coastal waters is *Epinephelus coioides* (syn. *E. suillus*), research effort focused on this species. This paper reviews the progress of research and development in breeding, seed production, nursery, and grow out culture of *E. coioides* at the SEAFDEC Aquaculture Department.

Broodstock Management

Epinephelus coioides like other Serranid species are protogynous hermaphrodites. They first mature as females at around 3 to 4 kg body weight. Some of the fastest growing females transform into males when they reach more than 6 kg body weight. Because of the difficulty in obtaining mature males, studies to develop methods to induce sex-inversion in juveniles and adults were undertaken (Tan-Fermin, 1992, Tan-Fermin et al. 1994). Female grouper juveniles (average body weight – 1.2 kg) were given bi-monthly intramuscular injections of 17-alpha methyltestosterone (mt) at doses

of 0.5 and 1.0 mg/kg BW and developed mature testes within five months of hormone administration (Tan-Fermin, et al. 1994). A few of these sex-inversed males produced milt in very small quantities. However, 8-9 months after cessation of hormone treatment, the sex-inversed males reversed back to females (Tan-Fermin, 1992).

Figure 1.



To avoid frequent handling during hormone administration, mt in silastic capsules were implanted in adult females at a dose of 4 mg/kg BW. Functional males were obtained within 7-10 weeks of hormone implantation and milting was maintained by implanting mt capsules every three months. Spontaneous spawning of females and the sex-inversed spawning of males produced viable eggs (Marte et al. 1994). Sex-inversion may also be enhanced by manipulating the social environment of groupers. A large female reared with several smaller females may spontaneously change to a male after 1-2 months of rearing in the same tank or cage (Quinitio et al. 1997).

Epinephelus coioides held in tanks or cages spawn monthly, usually within four days before or after the last quarter moon phase (Toledo et al. 1993). Spawning occurs for 5-17 successive days during each spawning run. However, the quantity and quality of eggs vary considerably between each spawning run and for individual spawns in a series. Occurrence and frequency of spawning also vary annually and may be related to environmental conditions. Attempts to improve egg quality by enriching feeds with oils containing high levels of highly unsaturated fatty acids (HUFA) such as cod liver oil or by feeding broodstock with fish-by catch known to have high levels of HUFA have been unsuccessful. Present efforts are geared at improving the quality of spawned eggs

through broodstock nutritional manipulation and determining morphological and biochemical parameters associated with good quality spawns.

Seed Production

Intensive larval rearing techniques developed for other marine species such as milkfish and rabbitfish were modified to suit the requirements of grouper larvae. Early trials used oyster trochophore, artificial plankton and rotifers as feed for early larvae with little success. Based on information on mouth gape of early feeding grouper larvae (Duray and Kohno, 1990), feeding behavior (Duray et al., 1996) and known requirement of marine fish larvae for high levels of HUFA, the rearing protocol developed for grouper larvae involved feeding young larvae (day 2-day 15 larvae) with small rotifers obtained by passing a mixed rotifer culture through a fine mesh screen (Fig.1, Duray et al., 1997). Rotifers were previously enriched with high HUFA containing commercial larval food boosters. Older larvae (day 20 to day 50) were fed with enriched *Artemia* nauplii or increasing sizes of *Artemia* until larvae metamorphosed to the juvenile phase when these were able to feed on minced trash fish. Survival rates for the first twenty-one days of culture improved considerably from less than 10% obtained during the early rearing trials to over 25% by using the improved feeding protocol.

Semi-intensive larval rearing using copepods collected from brackish water ponds as initial food for feeding grouper larvae has also been developed. The method differs from intensive rearing techniques in the low initial density of larvae used (10 larvae/l), minimal water change, and density of copepod nauplii fed to the larvae. Tests to determine food selectivity and feeding behaviour of grouper larvae indicated that the first feeding larvae preferred to feed on copepod nauplii..

Survival and growth of young larvae fed on copepod nauplii were also enhanced (Figure. 2).

Optimum densities of copepod nauplii and adults needed to support the food requirements of early feeding larvae were determined (Toledo et al., 1996). This information together with modifications on water and tank management were the basis of the semi-intensive rearing scheme developed for grouper larvae (Figure 3, Toledo et al., 1999).

Grouper larvae reared at low densities and fed copepod nauplii during the early rearing phase grew faster and had higher survival rates at least up to the metamorphic stage. The enhanced nutritional quality of copepods particularly that of *Acartia tsuensis* can be attributed to the high levels of n3-HUFAs in these organisms (Table 1), particularly the fatty acid, docosahexaenoic acid (DHA) (Table 2) (Toledo et al., 1999). Studies are being undertaken to refine this semi-intensive rearing scheme, which uses copepod as live food. Studies to develop mass production techniques for *Acartia* and other

Figure 2

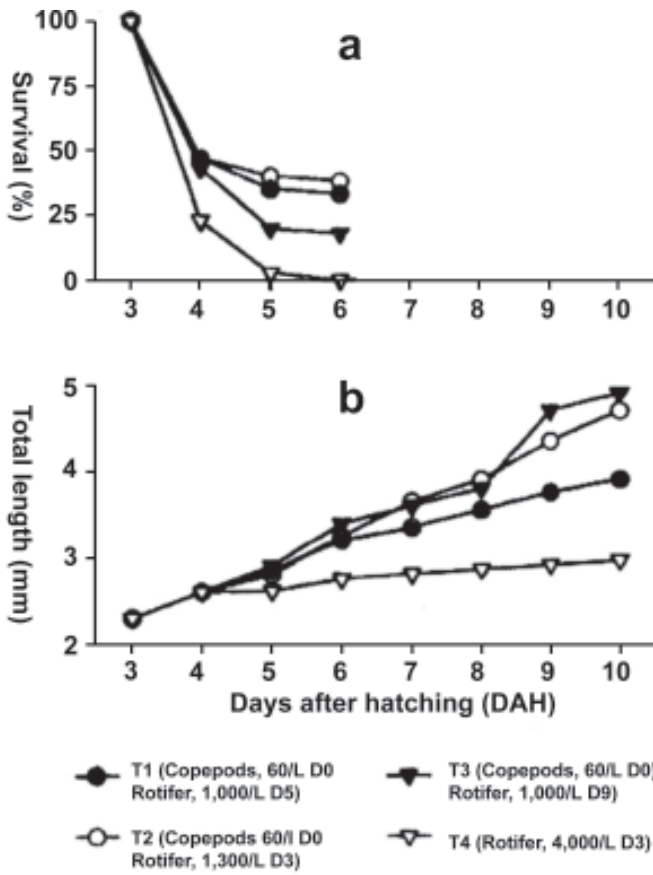
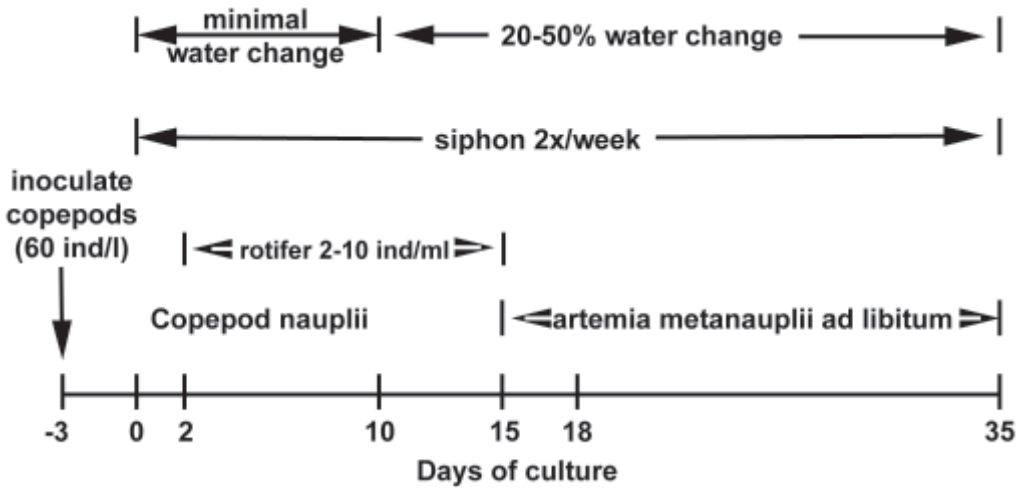


Figure 3.



copepods are also being undertaken to support the food requirement of grouper larvae.

Table 1: Fatty acid composition (% area) of food organisms used in the early feeding stages of grouper *E. coioides* larvae (From: Toledo et al. 1999)

Fatty Acid	<i>Pseudodiaptomus</i>	<i>Acartia</i>	<i>Oithona</i>	Rotifer
Σ Saturate	42.86	44.17	63.01	39.94
Σ Monoene	15.33	8.84	15.95	29.76
Σ n-6	7.72	8.14	1.60	10.50
Σ n-3	29.55	36.01	12.18	13.88
Σ n-3 HUFA	23.75	34.48	10.74	13.35
n-3/n-6	3.83	4.42	2.65	1.11
DHA/EPA	1.37	2.64	1.28	0.02

While improvement in growth and survival of the early larval stages (day 21 larvae) of *E. coioides* has been achieved in both intensive and semi-intensive hatchery rearing schemes, final survival rate grouper fry at harvest is still less than 5%. Grouper larvae undergo a long metamorphic phase before they assume the physical and behavioral characteristics of juvenile fish. Larval grouper undergoing metamorphosis are extremely sensitive to various stressors such as handling, water turbulence, and fluxes in environmental conditions. Metamorphosis involves resorption of the long dorsal and ventral fins, development of pigmentation patterns of adult fish, and assumption of benthic

Table 2: Fatty acid composition (% area) of food organisms used in the early feeding stages of grouper *E. coioides* larvae (From: Toledo et al. 1999)

Fatty Acid	<i>Pseudodiaptomus</i>	<i>Acartia</i>	<i>Oithona</i>	Rotifer
14:0	8.97	4.54	10.88	4.34
16:0	24.33	26.68	32.49	28.38
16:1	8.22	2.85	6.43	13.28
18:0	4.94	8.26	12.45	5.10
18:1	5.15	4.53	7.30	12.22
18:2n-6	2.15	2.35	1.28	6.07
18:3n-6	0.46	0.32	0.37	0.50
18:3n-3	3.45	0.99	0.47	0.16
18:4n-3	1.97	0.43	0.67	0.17
20:1	0.46	0.26	1.50	2.61
20:2n-6	0.41	0.37	0.24	0.12
20:4n-6	1.71	2.33	1.35	3.64
20:4n-3	0.57	0.20	0.22	0.46
20:5n-3	9.24	9.25	4.22	8.26
22:0	0.33	0.43	0.48	0.10
22:1	0.23	0.19	0.13	0.59
22:5n-6	1.79	2.09	0.33	trace
22:5n-3	0.89	0.58	0.69	4.39
22:6n-3	12.70	24.41	5.42	0.17
24:0	0.36	0.26	0.75	0.23

habits typical of the species. The process takes from 15 to 20 days and occurs when the larvae are between 21 and 35-40 days old (Doi et al., 1991).

The thyroid hormones, tri-iodothyronine (T3) and tetra-iodothyronine (T4) have long been known to enhance growth and accelerate metamorphosis in various vertebrates including fish such as flounder (Inui and Miwa, 1985). Following reports of Tay et al. (1994) on acceleration of metamorphosis in larval grouper, investigation of the response of various ages of grouper larvae to T3 and T4 treatments was performed. Two, three and four-week old groupers immersed in rearing water containing 1 ppm of either T3 or T4 had resorbed dorsal and ventral fins (shorter than controls) and developed pigment patterns of juveniles within 3 days of hormone treatment (de Jesus et al., 1998). The response of grouper larvae to the hormones was directly related to the hormone dose. Larvae immersed in the higher T3 or T4 dose (1 ppm) completed metamorphosis within two days; larvae treated with 0.01 ppm of the hormones completed metamorphosis in five to six days; while untreated controls took ten to twenty-one days to complete metamorphosis (de Jesus et al., 1998). The application of thyroid hormones in large-scale hatchery runs is presently being verified.

Nursery and Grow-out Culture

Most of the culture practices for on-growing groupers in cages or ponds were developed by fish farmers guided by their experience with other species. Continuing research to improve these farming practices is being undertaken. Grouper farmers use trash fish to feed groupers.

Trash fish feeding is not only inefficient as shown by its high feed conversion ratio (FCR), it also competes with the food requirements of human population particularly in countries like the Philippines. Major research to improve farming practices should focus on the development of cost-effective diets to replace trash fish. Practical diets based on the requirements of other carnivorous marine fish species such as seabass has been formulated. However, these feeds still contain considerable amounts of fishmeal.

Studies aimed at reducing the fish meal component of grouper feed are currently being pursued. The apparent digestibility of protein from alternative plant and animal sources, acceptability of compounded diets with these feed ingredients and growth of juvenile grouper fed these diets is being assessed. Among the locally available plant protein sources tested, preliminary results suggest that white cowpea meal can be used as a partial replacement for fishmeal in grouper diets (Eusebio, 1999, pers. com.). Other protein sources are being tested including commercially available meat soluble from slaughter house by-products.

Increasing numbers of fish farmers in the Philippines are now engaged in grouper culture. Mortalities, mostly from parasitic infestations, are an emerging problem. Cage-

reared groupers harbour more species of parasites with higher prevalence and intensity of infection than pond-cultured groupers (Lacierda, 1999 pers. com.). Parasites recovered from groupers cultured in ponds and cages include various species of protozoa, and parasitic flatworms and nematodes. Life cycles of more common monogeneans are also being studied.

Grouper research at the SEAFDEC Aquaculture Department will continue to focus on three major areas: broodstock development; seed production; and nursery and grow-out culture. The main objectives are: 1) to improve the quality of spawned eggs through improved broodstock nutrition; 2) to further improve seed production technologies that can be easily disseminated to private hatchery operators; 3) to develop cost-effective and environmentally-friendly feeds by searching for nutritionally adequate alternative protein sources to replace fish meal; and 4) to develop improved husbandry practices for cage and pond culture operations.

References

- De Jesus, E.G.T. Toledo, J.D. and Simpás, M.S. 1998.** Thyroid hormones promote early metamorphosis in grouper (*Epinephelus coioides*) larvae. Gen. Comp. Endocrinol. 112:10-16.
- Doi, M. Naudi, M.H.M. Nik, R.N.L. and Zulkifli, T. 1991.** Artificial Propagation of the Grouper, *Epinephelus suillus* at the Marine Finfish Hatchery in Tanjung Demong, Terengganu, Malaysia. Dept. of Fisheries, Ministry of
- Doi, M. Toledo, J.D. Golez, S.N. de los Santos, M. and Ohno, A. 1997.** Preliminary investigation of feeding performance of larvae of early red-spotted grouper, *Epinephelus coioides*, reared with mixed zooplankton. Hydrobiologia 358:259-263.
- Duray, M.N. and Kohno, H. 1990.** The relationship between mouth width and larval length to prey size in three marine fish species. Phil. J. Sc. 119:237-245.
- Duray, M.N. Estudillo, C.B. and Alpasan, L.G. 1996.** The effect of background color and rotifer density on rotifer intake, growth and survival of the grouper (*Epinephelus suillus*) larvae. Aquaculture 146:217-224.
- Duray, M.N. Estudillo, C.B. and Alpasan, L.G. 1997.** Larval rearing of the grouper *Epinephelus suillus* under laboratory conditions. Aquaculture 150: 63-76.
- Inui, Y. and Miwa, S. 1985.** Thyroid hormone induces metamorphosis of flounder larvae. Gen. Comp. Endocrinol. 60:450-454.
- Kohno, H. 1986.** An introduction to lapu-lapu (*Epinephelus*) in the Philippines. SEAFDEC Asian Aquacult. 8(6):8-11
- Kohno, H. 1987a.** An introduction to lapu-lapu (*Epinephelus*) in the Philippines. Part 2 of a series. SEAFDEC Asian Aquacult. 9 (1): 5,10.
- Kohno, H. 1987b.** An introduction to lapu-lapu (*Epinephelus*) in the Philippines. Part 3 of a series. SEAFDEC Asian Aquacult. 9(2):5-8.
- Kohno, H. 1987c.** An introduction to lapu-lapu (*Epinephelus*) in the Philippines. Last of a series. SEAFDEC Asian Aquacult. 9(3):5-8.
- Kohno, H. and Duray M. 1989.** Species composition of groupers in Iloilo market. Asian Aquaculture 11(3): 6-8.
- Kohno, H. Duray, M.N. and Juario, J.V. 1988.** State of grouper (Lapu-lapu) culture in the Philippines. SEAFDEC Asian Aquacult. 10(2):4-9.
- Kohno, H. Duray, M. and Sunyoto P. 1990.** A field guide to groupers of Southeast Asia. Pusat Penelitian dan Pengembang PHP/KAN/PT No. 14/1990. Jakarta. 26 p.
- Marte, C.L. Qunitio, G. and Caberoy, N. 1994.** Spontaneous spawning of sex-inversed grouper *Epinephelus coioides* administered 17-alpha methyl-testosterone implants. (Abstract) Fourth Asian Fisheries Forum 16-20 October 1995. Beijing, China p.5.

- Quinitio, G.F. Caberoy, N/B. and Reyes Jr. D.M. 1997.** Induction of sex change in female *Epinephelus coiodes* by social control. The Israeli Journal of Aquaculture – Bamidgeh 49:77-83.
- Tan-Fermin, J.D. 1992.** Withdrawal of 17 alpha-methyltestosterone causes reversal of sex-inversed male grouper *Epinephelus suillus* (Valenciennes). Philipp. Scient. 29:33-39.
- Tan-Fermin, J.D. Garcia, L.M.B. and Castillo, A.R. 1994.** Induction of sex inversion in juvenile grouper *Epinephelus suillus* (Valenciennes) by injections of 17 alpha-methyltestosterone. Jpn. J. Ichthyol. 40:413-420.
- Tay, H.C. Goh, J. Yong, A.N. Lim, H.S. Chao, T.M. Chou, R. and Lam, T.J. 1994.** Effect of thyroid hormone on metamorphosis in greasy grouper *Epinephelus tauvina*. Singapore J. Pri, Ind. 22(1):35-38.
- Toledo, J.D. Nagai, A. Javellana, D. 1993.** Successive spawning of grouper, *Epinephelus suillus* (Valenciennes) in a tank and a floating net cage. Aquaculture 115:361-367.
- Toledo, J.D. Golez, S.N. and Doi, M. 1996.** Preliminary studies on the rearing of the red-spotted grouper, *Epinephelus coiodes* larvae using copepod nauplii as initial food. UPV J. Nat. Sci. 1:119-129.
- Toledo, J.D. Golez, S.N. Doi, M. and Ohno, A. 1997.** Food selection of early grouper, *Epinephelus coiodes*, larvae reared by the semi-intensive method. Suisanzoshoku 45(3): 327-337.
- Toledo, J.D. Golez, S. Doi, M. and Ohno, A. 1999.** Use of copepod nauplii during early feeding stage of grouper *Epinephelus coiodes*. Fisheries Science. 65(3):390-397.

**Collaborative
APEC Grouper Research and Development Network
(FWG 01/99)**

Report of the APEC/NACA Cooperative Grouper Aquaculture Workshop

**Hat Yai, Thailand
7-9 April 1999**

Report prepared by:



Network of Aquaculture Centres in Asia-Pacific (NACA)

Suraswadi Building
Department of Fisheries
Kasetsart University Campus
Ladyao, Jatujak
Bangkok 10900
Thailand

Tel: +66 2 561 1728 (to 29)

Fax: +66 2 561 1727

E-mail: naca@enaca.org

Website: <http://www.enaca.org/>

For:



Copyright © 2002 APEC Secretariat

APEC Secretariat

438 Alexandra Road

#14-01/04 Alexandra Point

Singapore 119958

Tel: +65 276 1880

Fax: +65 276 1775

E-mail: info@mail.apecsec.org.sg

Website: <http://www.apecsec.org.sg>

APEC Publication Number: APEC#202-FS-04.1