



International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia

Challenges in Responsible Production of Aquatic Species

**5-7 March 2014
Punta Villa Resort
Iloilo City, Philippines**

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Overview

The Southeast Asian region has highly diverse marine flora and fauna. Many of these aquatic species have been utilized for human food and trade, and yet continuously over-exploited for decades. As a consequence, many species in the region have become threatened or endangered. Public concern in environmental protection and marine resource conservation has also been heightened. Immediate action towards replenishment of the over-exploited species is needed to maintain and secure a wholesome ecosystem, which also supports sustainable fisheries for food security and livelihood in the region.

Organized by SEAFDEC Aquaculture Department with funding from the Government of Japan, the 3-day International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia aims to promote and augment regional initiatives on resource enhancement and sustainable aquaculture practices, and to contribute to poverty alleviation, livelihood and food security.

Topics:

1. Country Reports

SEAFDEC member-countries shall present status reports on resource enhancement and sustainable aquaculture practices including pressing issues, gaps, possible strategies and their respective recommendations.

2. Contributed Papers on the following topics:

- Establishment of stock enhancement strategies for over-exploited and/or endangered species;
- Resource enhancement through community-based management;
- Refinement of hatchery and nursery technologies;
- Updates on seed production technologies;
- Genetics in aquaculture and stock enhancement;

- Feed development and management;
- Good aquaculture practices/responsible aquaculture;
- Affordable and economically viable aquaculture technologies;
- Sustainable utilization of aquatic species and environment; and,
- Other matters supporting resource enhancement and sustainable aquaculture practices.

3. Workshop Discussion

Research gaps and collaborative activities among member-countries shall be identified, such as, but not limited to: needs and requirements of member-countries to promote resource enhancement and sustainable aquaculture practices, special needs of member-countries for learning procedures and methodologies for the respective practices, and application of knowledge and utilization of available resources and training needs of personnel in member-countries.

Expected outputs:

Participants will acquire knowledge on practical information and skills which could be utilized for resource enhancement and promotion of sustainable and environment-friendly aquaculture practices.

Organizing Committee

Chairperson

Dr. Teruo Azuma

Scientific Program Committee

Dr. Ma. Junemie Hazel Leбата-Ramos

Dr. Ma. Rowena R. Eguia

Dr. Fe Dolores Prado-Esteba

Dr. Nerissa Salayo

Members

Mr. Stephen B. Alayon

Dr. Frolan Aya

Dr. Evelyn Grace D. Ayson

Ms. Nanette C. Bantillo

Mr. Norwell Brian C. Bautista

Ms. Richelle T. Bautista

Ms. Shelah Mae Buen-Ursua

Ms. Milagros T. Castaños

Mr. Demy Catedral

Ms. Kaylin G. Corre

Mr. Caryl M. Genzola

Dr. Frances Nievaes

Dr. Fiona Pedroso

Dr. Eleonor A. Tendencia

Dr. Jacque Zarate

Message

I welcome all the participants, guests and visitors to this International Workshop on Resource Enhancement and Sustainable Aquaculture here in Iloilo City. For the participants from other countries who visit the Philippines for the first time, welcome to our country as well.

This workshop, supported by the Government of Japan, brings to the fore two important activities, sustainable aquaculture and resource enhancement. The former has been the focus of the farming activities these days considering its importance as a means of generating food for the people. The latter is undertaken in order to replenish stocks whose natural population are dwindling because of excessive exploitation. Given the rate at which human population are extracting resources from our coastal waters, many of the natural stocks will soon perish if no management and conservation measures will be put in place. Assessment of the natural stocks is undertaken in order to evaluate the present state of the resource and to determine how much damage has been done. The resource can then be aided to gradually return back to its former state by releasing some stocks back into the natural waters and instituting a catch management plan for that specific resource. The management and conservation plan, if properly implemented and enforced, will ensure the availability of the resource for the benefit of the future generations.

In this gathering, many lessons will be learned from the various country papers that describe their efforts toward this goal. Presentations from the experts in the field will undoubtedly enhance our present understanding of the topic. May this meeting also serve as an opportunity to rekindle professional and social ties among colleagues, and probably forge future collaborations among newly-found friends and acquaintances.

I hope that you will also find time to visit important sights in Iloilo City for you to remember. The main station of SEAFDEC/AQD is just 25 km away from the meeting venue. I hope you can also find time to visit our station.

May God bless us all.



Felix G. Ayson, D. Sc.
Chief
SEAFDEC AQD

Message



Greetings from the Aquaculture Department of the Southeast Asian Fisheries Development Center, (SEAFDEC/AQD), Iloilo, Philippines, and welcome to the **International Workshop on Resource Enhancement and Sustainable Aquaculture (RESA) Practices in Southeast Asia!**

The Southeast Asian region has highly diverse marine flora and fauna. Many of these aquatic species have been utilized for human food and trade, and yet have been continuously over-exploited for decades. As a consequence, many species in the region have become threatened or endangered. The fact that world capture production have almost reached saturation levels and since mid-1990s, started to gradually decline, also indicates that fishing pressure on even commercially available species have already attained the upper limit of maximum utilization. Public concern in environmental protection and marine resource conservation has also heightened. Immediate action, especially towards replenishment of the over-exploited species is needed to maintain and secure a wholesome ecosystem, which also supports sustainable fisheries for food security and livelihood in the region.

Aquaculture, on the other hand, is undoubtedly a practical way to reduce fishing pressure on wild aquatic species and is an effective measure to fulfill man's demand for food fish without adversely affecting wild resources. Aquaculture has continuously been addressing the issues of food security and widespread poverty in the Southeast Asian region. Nowadays, culture production in Asia accounts for 91.5 % of the world production. In 2010, four SEAFDEC Member Countries, *i.e.* Indonesia, Vietnam, Philippines, and Thailand, were included in the top ten aquaculture producers in the world. Indeed, the remarkable increase in aquaculture was more pronounced in the Southeast Asian region compared to the world as shown in the increase of culture production in 2010 compared to that in 2001, showing 3.52 versus 1.78 times, respectively. However, the rapid growth in aquaculture has also brought negative impacts such as: degradation of culture sites, destruction of sensitive ecosystems, decrease in bio-diversity, spread of diseases, social conflicts, *etc.* Not a few broodstock and fry of

particularly high value species still depend on wild resources. Hence, fishing pressure on these species has seriously affected the sustainability of the coastal resources. All of these factors hinder sustainability in aquatic food production. Thus, aquaculture activities present not only beneficial impacts but unfortunately also, a lot of issues which should be improved and established such as environment-friendly approaches, efficient seed production technologies in more species, *etc.*

Taking a brief look at the present status as mentioned above, endeavors toward resource enhancement and sustainable aquaculture practices are considered to complement efforts in securing livelihood and decreasing poverty in Southeast Asia in harmony with natural environment and ecosystems. Thus, “***Challenges in responsible production of aquatic species***” is considered to be strongly pursued, and is an apt theme for this workshop. To practically address the issues on RESA practices and to raise the awareness and commitment in promoting and augmenting regional initiatives on the practices, this workshop was organized with the following three major components, covering; 1) Status reports of SEAFDEC member countries on RESA practices including pressing issues, gaps, possible strategies, and recommendations in their respective countries; 2) Contributed papers on various aspects/ topics essential for RESA practices and; 3) Workshop Discussion on “Identification of research gaps and collaborative activities among member countries.”

Through the 3-day-long international workshop on resource enhancement and sustainable aquaculture practices in Southeast Asia, SEAFDEC Aquaculture Department highly wish to promote and augment regional initiatives on resource enhancement and sustainable aquaculture practices, with the ultimate aim of understanding issues on how such initiatives can contribute to poverty alleviation, promote livelihood and food security. At the end of the workshop, participants will be updated on the issues, and an increase in the awareness and commitment to enhance and support R&D towards wholesome and responsible production of aquatic species shall be achieved.

In behalf of the organizing committee of this workshop, we would like show our sincerest appreciation as we receive the many interests and concerns of the various sectors comprising of scientific research organizations; academes; private companies; local government units; national governments; and many others domestically, regionally and internationally.

I also would like to express my gratitude to all the participants for

their active contribution to this workshop. Many thanks are also due to the governments; and many others domestically, regionally and internationally.

I also would like to express my gratitude to all the participants for their active contribution to this workshop. Many thanks are also due to the members of the workshop committee who efficiently accomplished the required preparations leading to the success of this workshop. Lastly, I wish to acknowledge the Fisheries Agency of the Government of Japan for providing financial support for the conduct of this workshop.

Teruo Azuma, Ph. D.

Chairperson, Organizing Committee,

Deputy Chief & Co-Manager of GOJ-TF Program, SEAFDEC/AQD

Scientific Program

5 March 2014, Wednesday

07:20-08:20 Registration

08:20-09:30 Opening ceremonies

Master of Ceremonies: Dr. Edgar Amar

Welcome Remarks

Dr. Felix G. Ayson
SEAFDEC/AQD Chief

Opening Remarks

Dr. Teruo Azuma
Chair, RESA 2014 Organizing Committee

Message

Atty. Asis Perez
Director, Bureau of Fisheries and Aquatic Resources

Keynote Address

Dr. Chumnarn Pongsri
Secretary General, SEAFDEC

Ribbon cutting

09:30-09:45 Coffee break

COUNTRY REPORT SESSION

Moderator: Dr. Relicardo Coloso and Dr. Rolando Pakingking Jr.

09:45-10:15 **Country Report 1-** Cambodia: Current Status of Aquaculture in Cambodia
Ouch Lang

10:15-10:45 **Country Report 2-**Indonesia: Current Status of Aquaculture and Resource Enhancement in Indonesia
Setiawan Soetardjo

- 10:45-11:15 **Country Report 3**-Japan:Status reports of Japan on Resource Enhancement and Sustainable Aquaculture Practices
Dr. Koichi Okuzawa
- 11:15-11:35 **Country Report 4**-Lao PDR: Current Status of Resource Enhancement in Lao PDR
Yaipasong Meuansitthida
- 11:35-11:55 **Country Report 5**-Lao PDR: Current Status of Aquaculture in Lao PDR
Thongkhoun Khonglialiane
- 11:55-13:00 LUNCH BREAK
- 13:00-13:30 **Country Report 6**- Malaysia: Current Status of Resource Management and Aquaculture in Malaysia
Aishah Yusoff
- 13:25-13:55 **Country Report 7**- Myanmar: Current Status of Aquaculture in Myanmar
Sone Mine
- 13:55-14:15 **Country Report 8**- Myanmar: Fisheries Resource Enhancement in Myanmar
Htun Thein
- 14:15-14:45 **Country Report 9**- Philippines: The Philippine National Aquasilviculture Program (PNAP): Resource enhancement and sustainable aquaculture initiatives of the Bureau of Fisheries and Aquatic Resources
Florida C. Dieta
- 14:45-15:15 **Country Report 10**- Singapore: Current Status of Aquaculture in Singapore
Chin Heng

- 15:15-15:45 **Country Report 11-** Thailand: Milkfish: New Choice for Aquaculture in Thailand
Prapat Kosawatpat
- 15:45-16:15 **Country Report 12-** Vietnam: Solution for Sustainable Aquaculture Development in Vietnam in the Period of 2013-2015
Nguyen Thi Bang Tam
- 16:15-16:45 Open Forum
- 16:45-18:00 Poster Session
- 18:00 Dinner (Cultural Night)

6 March 2014, THURSDAY

Master of Ceremonies: Dr. Edgar Amar

PLENARY LECTURE SESSION

- 08:30-09:10 **Plenary Speaker 1-** Is Small-hold Tropical Aquaculture in a Genetic Plunge towards Extinction?
Dr. Roger W. Doyle (Gene Comp Ltd.)
- 09:10-09:50 **Plenary Speaker 2-** Rapid Adaptation to a New Environment: Is it Reversible?
Dr. Hitoshi Araki (Hokkaido University)
- 09:50-10:10 Coffee Break

CONTRIBUTED PAPER SESSION A

ESTABLISHMENT OF STOCK ENHANCEMENT STRATEGIES FOR OVEREXPLOITED AND/OR ENDANGERED SPECIES

Moderator: Dr. Jacques Zarate

- 10:10-10:30 **Contributed Paper 1-** Assessment of Napoleon Wrasse, *Cheilinusundulatus*, Spawning Aggregations and Declaration of Marine Protected Areas as Stock Enhancement of Wild Stock Strategy
Dr. Filemon Romero (Mindanao State University)
- 10:30-10:50 **Contributed Paper2-** SEAFDEC/AQD Stock Enhancement Initiatives: Release Strategies Established
Dr. Ma. Junemie Hazel L. Ramos (SEAFDEC/AQD)
- 10:50-11:10 **Contributed Paper3-** Stock Assessment of Christian Crabs (*Charybdis feriatius*, Linnaeus, 1758) in San Miguel Bay
Dr. Plutomeo Nieves (Bicol University)

CONTRIBUTED PAPER SESSION B

RESOURCE ENHANCEMENT THROUGH COMMUNITY BASED MANAGEMENT

Moderator: Dr. Jacques Zarate

- 11:10-11:30 **Contributed Paper4-** Abalone Aquaculture for Stock Enhancement and Community Livelihood Project in Northern Palawan, Philippines
Dr. Benjamin Gonzales (Western Philippines University)
- 11:30-11:50 **Contributed Paper 5-**Community-based Stocking of Abalone in Sagay Marine Reserve, Negros Occidental, Philippines
Dr. Nerissa D. Salayo (SEAFDEC/AQD)
- 11:50-12:10 **Contributed Paper6-** Community-based Stock Enhancement for Coastal Socio-ecological Restoration
Dr. Jon Altamirano (SEAFDEC/AQD)
- 12:10–13:10 Lunch Break

13:10-13:30 **Contributed Paper 7**-BFAR-CHED Philippine National Aquasilviculture Program (PNAP) in Bataan
Rudy C. Flores (*Bataan Peninsula State University*)

CONTRIBUTED PAPER SESSION C
REFINEMENT OF HATCHERY AND NURSERY TECHNOLOGIES

Moderator: Dr. Jon Altamirano

13:30-13:50 **Contributed Paper 8**- Marine Fish Hatchery: Development and Future Trends
Dr. Clarissa L. Marte (*Integrated Services for the Development of Aquaculture and Fisheries*)

1350-14:10 **Contributed Paper 9**-Hatchery Management Techniques of Tiger-tail Seahorse, *Hippocampus comes*
Shelah Buen Ursua (*SEAFDEC/AQD*)

14:10-14:30 **Contributed Paper 10**-Refinements in Postlarval Phase of Sandfish (*Holothuria scabra*) Culture
Frances Nievaes (*University of the Philippines - Visayas*)

CONTRIBUTED PAPER SESSION D
UPDATES ON SEED PRODUCTION TECHNOLOGIES

Moderator: Dr. Jon Altamirano

14:30-1450 **Contributed Paper 11**-Updates on the Seed Production of Mudcrab
Dr. Emilia T. Qunitio (*SEAFDEC/AQD*)

1450-15:10 **Contributed Paper 12**-Induced breeding of Giant Trevally, *Maliputo (Caranxignobilis)*
Frederick B. Muyot (*BFAR - National Fisheries Research and Development Institute*)

15:10-15:30 **Contributed Paper 13**-Seed production of Blue Swimming Crab Juveniles
Nonita S. Cabacaba (*BFAR - National Fisheries Research and Development Institute*)

CONTRIBUTED PAPER SESSION E
GENETICS IN AQUACULTURE AND STOCK ENHANCEMENT
Moderator: Dr. Jon Altamirano

15:30-15:50 **Contributed Paper 14**-Potential Genetic Impacts of Hatchery Based Resource Management
Dr. Zubaida U. Basiao (*University of the Philippines - Diliman*)

15:50-16:10 **Contributed Paper 15**-Marker-aided Genetic Stock Management: Prospects in Philippine Aquatic Biodiversity Conservation and Aquaculture
Dr. Maria Rowena R. Romana-Eguia (*SEAFDEC/AQD*)

16:10-16:30 Open Forum

16:30-17:30 Poster Session

17:30-1800 Product demo

18:00 Dinner

7 March 2014, FRIDAY

Master of Ceremonies: Dr. Edgar Amar

CONTRIBUTED PAPER SESSION F
FEED DEVELOPMENT AND MANAGEMENT
Moderator: Dr. Fe Dolores P. Estepa

08:20-08:40 **Contributed Paper 16**-Feed Management for Sustainable Aquaculture
Dr. Relicardo M. Coloso (*SEAFDEC/AQD*)

- 08:40-09:00 **Contributed Paper 17-** Potential of Cowpea *Vigna unguiculata* Meal as Alternative Plant Protein Source for Fishmeal in Diets for Giant Freshwater Prawn *Macrobrachium rosenbergii*(de Man)
Dr. Frolan A. Aya (*SEAFDEC/AQD*)
- 09:00-09:20 **Contributed Paper 18-** Application of the United States Soybean Export Council Program's Low Volume, High Density Cage Aquaculture Technologies and Soy Optimized Floating Feeds in Fish Cage Culture
Levy Loreto L. Manalac (*United States Soybean Export Council*)
- 09:20-09:40 Coffee Break

CONTRIBUTED PAPER SESSION G

GOOD AQUACULTURE PRACTICES / RESPONSIBLE AQUACULTURE

Moderator: Dr. Fe Dolores P. Estepa

- 09:40-10:00 **Contributed Paper 19-** Good Aquaculture Practices (GAQP): Setting Directions for a Harmonized Regional Standards, the Philippine experience
Dr. Nelson Lopez (*BFAR*)
- 10:00-10:20 **Contributed Paper 20-** Responsible Shrimp Culture through Ecological Approaches
Dr. Eleonor A. Tendencia (*SEAFDEC/AQD*)
- 10:20-10:40 **Contributed Paper 21-** Utilization of Sensors and SMS Technology to Remotely Maintain the Level of Dissolve Oxygen, Salinity and Temperature of Fishponds
Rodrigo C. Munoz Jr. (*Bataan Peninsula State University*)

CONTRIBUTED PAPER SESSION H
AFFORDABLE AND ECONOMICALLY VIABLE AQUACULTURE
TECHNOLOGIES

Moderator: Dr. Nerissa D. Salayo

- 10:40-11:00 **Contributed Paper 22-** Reaching the Poor through Aquaculture: The Case of Technology Adoption in Rural Communities at West Central Philippines
Didi Baticados (*SEAFDEC/AQD*)
- 11:00-11:20 **Contributed Paper 23-**The Economics of Aquaculture Development: Sustainability and Food Security
Dr. Maripaz Perez

CONTRIBUTED PAPER SESSION I
SUSTAINABLE UTILIZATION OF AQUATIC SPECIES AND ENVIRONMENT

Moderator: Dr. Nerissa Salayo

- 11:20-11:40 Contributed Paper 24-The Importance of Mangroves to Capture and Culture Fisheries
Dr. Jurgenne H. Primavera (*Zoological Society of London*)
- 11:40-12:00 **Contributed Paper 25-**Marine Biodiversity at the SEAFDEC/AQD Aquaculture Stations in Iloilo and Guimaras, Philippines
Dr. Teodora Bagarinao (*SEAFDEC/AQD*)
- 12:00-12:20 **Contributed Paper 26-**Estimation of Energy Budget of Sea Cucumber, *Holothuria scabra*, in Integrated Multi-trophic Aquaculture
Dr. Satoshi Watanabe (*Japan International Research Center for Agricultural Sciences*)
- 12:20-13:20 LUNCH BREAK

CONTRIBUTED PAPER SESSION J
OTHER MATTERS SUPPORTING RESOURCE ENHANCEMENT AND
SUSTAINABLE
AQUACULTURE PRACTICES

Moderator: Dr. Nerissa Salayo

- 13:20-13:40 **Contributed Paper 27**-Stock Enhancement? Why Bother
Dr. Jose Ingles (*World Wildlife Fund*)
- 13:40-14:00 **Contributed Paper 28**-The Battle against WSSV: Targeting
Essential Genes for RNA Interference to Revive the Ailing
Shrimp Industry
Dr. Marybeth Maningas (*University of Sto. Tomas*)
- 14:00-14:10 Open Forum

WORKSHOP DISCUSSION

Moderator: Dr. Maria Rowena R. Romana-Eguia

- 14:10-14:20 Workshop Mechanics
Dr. Ma. Junemie Hazel L. Ramos
- 14:20-15:50 Workshops: Break-out sessions
- 15:50-16:20 Workshop Outputs
- 16:20-16:30 Summary of Workshop Outputs
Dr. Leobert de la Peña
- 16:30-17:00 Closing Ceremonies
Impressions on the Workshop
Dr. Roger W. Doyle (Gene Comp Ltd.)
Dr. Hitoshi Araki (Hokkaido University)
- Closing Remarks
Dr. Ma. Junemie Hazel L. Ramos

ABSTRACTS OF COUNTRY REPORTS

CR 1

Current Status of Sustainable Aquaculture in Cambodia

OUCH Lang

*Department of Aquaculture Development of Fisheries Administration
#186, Preah Norodom Blvd, P.O Box582, Phnom Penh, Cambodia
langouch@yahoo.com*

In Cambodia, the extension of technologies in fish aquaculture is a vital activity that contributes to improving the daily livelihood of the rural poor farmer community. Technology extension was introduced since 1994 by an Asian Institute of Technology (AIT) Project and other local non-government organizations (NGOs) or International Organizations (IOs) in some fish production deficient provinces as prior to the introduction of such activities, wild fish are still abundant. From then until now aquaculture extension is being done by the Freshwater Aquaculture Improvement and Extension Project phase II supported by the Japan International Cooperation Agency (FIAEXII-JICA) and the Department for International Development / Danish International Development Agency (DFID/DANIDA) Projects.

Recently, aquaculture extension is one of the national policies under the National Rectangular Strategy Policies of the Government. There are several different freshwater aquaculture systems including floating cage/pen culture, earthen pond culture and rice-fish culture, and other fish culture in small-water bodies or aquaculture-based fisheries in Cambodia as practiced in over 20 of provinces and cities with less development focused on coastal aquaculture.

Freshwater aquaculture production continued to show growth over the past two decades and increased from 1,610 in 1984 to 20,760 tons in 2004, representing an 11.9-time increase or a growth of 16.3% per year, and increased to 74, 000 tons in 2012, representing an increase or a growth rate of 15% per year However, aquaculture development in Cambodia is in its infancy stage of development compared to other countries in the region, and it has some problems and constraints encountered in its development which

include inadequate and unreliable supply of good quality seed; lack of capital, fund or credit for aquaculture investment; inadequate knowledge of aquaculture technology; inadequate manpower for aquaculture extension service; and climate change, which have adversely impacted aquaculture development in Cambodia.

In order to achieve the goal of aquaculture fish production to supply the nation's future fishery requirements, the Cambodia Fisheries Administration has already published the Strategic Planning Framework (SPF) for Fisheries (2010-2019). Within this framework, the scenarios for future fish demand-supply for 2019 suggested aquaculture production will increase by 15% per year to 185,000 tons by the end of 2019.

CR2

Sustainable Aquaculture and Resources Enhancement In Indonesia

SetiawanandIrham Adhitya

Directorat General of Aquaculture
Ministry of Marine Affairs of Fisheries
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Indonesia
e-mail: setiawan2003@yahoo.com

Indonesia has a population of 230 million. The country has huge potential for marine and fisheries resources development. Aquaculture is being promoted as a major sector to accelerate economic growth for rural communities. Recently, initiatives have been done to improve Indonesia's legal framework to mitigate the adverse impacts of aquaculture and make it more sustainable.

The Directorate General of Aquaculture, Ministry of Marine Affairs and Fisheries (MMAF) Republic of Indonesia has a mandate to develop aquaculture sectors in Indonesia. Aquaculture has an important role in the development of the national economy and plays a key role in rural development. As the demand for aquaculture products expand, there is a growing concern over the impacts of aquaculture on the sustainability of resources and the need for enhancement of depleted resources. There is also the challenge posed by quality and food safety requirements for fish products.

For this reason, there is a need to improve aquaculture technologies and management systems in Indonesia to address eco-friendly production processes, food safety concerns, and the sustainability of aquaculture in the country. Indonesian Fisheries Act No 31 (2004) Amendment No. 45 (2009) mentioned, among others, that the Indonesian Fisheries Management should create job opportunities, improve welfare of fishers and related communities, while ensuring the sustainability of fisheries and environmental resources. Consistent with these goals, MMAF has recently

established the Sustainable Marine and Fisheries Development policy which is based on the concept of Blue Economy.

Some of the most critical factors to achieve sustainable aquaculture in Indonesia are availability of good quality seed, employment of good management practices in grow-out systems, maintenance of good aquaculture environments, fish health management, good quality and safe products, and effective marketing system, and aquaculture's contribution to enhancement of depleted stocks.

CR 3

Status reports of Japan on resource enhancement and sustainable aquaculture practices

Koichi Okuzawa^{1*}, Takayuki Takebe², Narisato Hirai³ and Kazumasa Ikuta⁴

¹National Research Institute of Aquaculture, Fisheries Research Agency, 422-1 Nakatsuhamaura, Minami-ise, Watarai, Mie 516-0193, Japan, ²Research Center for Subtropical Fisheries, Seikai National Fisheries Research Institute, Fisheries Research Agency, Ishigaki, Okinawa 907-0451, Japan ³Shibushi Laboratory, National Research Institute of Aquaculture, Fisheries Research Agency, 205 Natsui, Shibushi, Kagoshima 899-7101, Japan ⁴Counsellor, Resource Enhancement Promotion Department, Japan Fisheries Agency, Ministry of Agriculture Forestry and Fisheries, 1-2-1 Kasumigaseki, Chiyoda, Tokyo 100-8907, Japan
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Contrary to the rapid increase in world aquaculture production, a slight reduction has been noted in Japan due to the decreasing trend in the consumption of seafood by the Japanese. The aquaculture industry has contributed in compensating for the decrease in fisheries production in Japan as it provides approximately 20% in yield, and 30% in terms of market value, to the country's total fisheries production. The highest production for finfishes was that of yellow tail, *Seriola quinqueradiata* (104,000 t) followed by red seabream *Pagrus major* (61,000 t). For shellfishes, scallops, *Mizuhopectenyessoensis*, (220,000t) and oyster, *Crassostrea gigas*, (200,000t) are the major commodities, and laver, *Porphyra yezoensis*, (329,000t) dominates seaweed production from aquaculture. The prawn culture industry is rather small in Japan with kuruma prawn, *Marsupenaeus japonicus*, being produced at 1,600 t. All statistics are from the Japan Fisheries Agency in 2011.

In Japan, about 80 species are targeted for sea ranching and resource enhancement. The local governments (prefectures) play major roles in resource enhancement programs. Chum salmon, *Oncorhynchus keta*, is an example of successful resource enhancement in Japan with around 1.7 billion fries being released and 50-70 million salmon returning (or a

recovery rate of 2-3%) every year. Scallop sea ranching is another success story, where about 3 billion spats are released and 300,000 t scallops harvested per year. Chum salmon (129,000 t) and scallop (302,000 t) yields explain about 40 % of the total production of coastal fisheries (1,129,000 t) in Japan in 2011. Japanese (olive) flounder, *Paralichthys olivaceus*, and red seabream represent priority stock enhancement commodities, with around 15 and 12 million juveniles released respectively in 2011. Around 10% of total catch of those species are estimated as released fish.

This paper discusses the current status of sustainable aquaculture and stock enhancement initiatives in Japan and identifies pressing issues and possible strategies to address concerns pertaining to fish production and resource management.

CR 4
Current Status of Resource Enhancement in Lao PDR

Xaipsong Meuansitthida

CR 5

Current Status of Aquaculture in Lao PDR

Thongkhoun Khonglaliane

CR6

Status of Resource Management and Aquaculture in Malaysia

Aishah Yusoff

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Malaysia is a maritime nation and the fishing industry is a source of income for 134,000 fishermen. In 2012, the fisheries sector produced 1.7 million tons of fish valued at RM10.8 billion and generated trade worth RM6 billion. The landings from capture fisheries are expected to increase from 1.32 million tons in 2010 to 1.76 million tons in 2020 at an annual growth rate of 2.9%. In 2012, 65% of total catch was contributed by the coastal fisheries as compared to 35% from deep sea fishing. Landing from deep sea fishing is expected to rise from 381,000 tons in 2012 to 620,000 tons in 2020. Deep sea fishing has been identified for its potential to contribute to the increase in the country's fish production. With a growing population and an increasing preference for fish as a healthy source of animal protein, the National Agro-food Policy, 2011-2020 estimated that the annual demand for fish will increase to 1.93 million tons by the year 2020. The Department of Fisheries (DOF) has developed the Capture Fisheries Strategic Management Plan (2011-2020) based on three main documents i.e. National Agro-food Policy (NAP, 2011-2020), Department of Fisheries Strategic Management Plan (2011-2020), and Malaysia National Plan of Action on Sustainable Fisheries for Food Security towards 2020.

Aquaculture is now being promoted in Malaysia as an important engine of growth and eventually to become the mainstay of the nation's economy. Situated in a region with abundant supply of land and water, two determinant factors for aquaculture activities, Malaysia has always strived to ensure that this sector is not sidelined in their development efforts. With a growing population and an increasing preference for fish as a healthy

source of animal protein, it has been estimated that the annual demand for fish will increase to 1.7 million tons in 2011 and further to 1.93 million tons by 2020. From the present annual aquaculture production of about 525,000 tons, this output would need to be raised to 790,000 tons to meet the projected demand by 2020. In a move to develop the aquaculture industry, the DOF has initiated the Aquaculture Industrial Zone (AIZ) Program involving the development of 49 zones, located across Malaysia, which will be used for culture of various types of high value aquatic species. The DOF has identified several strategic areas that would be developed for downstream activities such as fish seed production, feed mills, fish processing plants, and other supporting industries. Aquaculture is also currently listed among the 16 Agro-food's Entry Point Projects (EPP) of the National Key Economic Area (NKEA). The government aims to double the Agro-food sector's contribution to Gross National Income (GNI) from RM20.2 billion in the year 2010 to RM49.1 billion by 2020, or an increase of RM28.9..

CR7 Current Status of Aquaculture in Myanmar

Sone Mine

Department of Fisheries, Myanmar

The agriculture and fishery sector plays a crucial role in contributing to the social and economic development of the Republic of the Union of Myanmar where the people are traditionally enormous consumers of rice and fish. In Myanmar, the agriculture and fishery sector plays a crucial role in contributing to the social and economic development of Myanmar where the people are traditionally major consumer of rice and fish. Fish is regarded as one of the most important diets in Myanmar since more than 70% of animal protein is taken from fish and fishery products. According to the statistics of 2012-2013, the country has a population of 61 million and the per capita consumption of fish was 56 kg. The Aquaculture Division is responsible for producing good quality fish and prawn/shrimp seeds for the fish farmers, to: (a) ensure replacement of fish and prawn seeds into the natural water reservoir and man-made water bodies, (b) conduct research on marine and freshwater aquaculture, (c) educate and transfer aquaculture technologies to fish farmers and (d) conduct environment-friendly aquaculture methods for sustainable fisheries development. Currently, over 20 species of freshwater fishes such as major and common carps, tilapia and catfishes are being cultured. Rohu (*Labeorohita*) is the most common commercial culture species which is native to Myanmar. In order to promote and distribute quality fish seed, the Department of Fisheries (DoF) has tried to upgrade broodstocks through its 27 fishery stations that are conducting seed production and providing technical assistance to farmers. Moreover, in order to increase fish production and supplementary income, the Department also initiated the paddy cum fish farming in appropriate regions through demonstration. About 18,547 acres of paddy fields in States and Divisions were stocked with fish seed in 2012-2013. The most common and prioritized species is the commercially important giant freshwater prawn,

Macrobrachium rosenbergii. *Penaeus monodon* farming has been initiated since early 1980 while short and long term genetic improvement in Rohu (*Labeorohita*) has been carried out by DoF since 2009, out short and long term genetic improvement .For farming marine finfishes, seabass, red snapper and grouper are the most common commercial species in Myanmar. *Eucheuma* seaweed farming began in 2003 through a collaboration with a private Korean company. There are considerable opportunities for further development in aquaculture. Joint efforts of the government and the private sector would realize for the nation and the people, huge aquaculture potentials. It has, for instance, tasked the DoF with the responsibility of promoting the conservation of biodiversity and habitats and providing assistance to all forms of aquaculture.

CR 8

Fisheries Resource Enhancement in Myanmar

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Myanmar has impressive freshwater capture fisheries. Inland freshwater bodies cover 8.1 million ha of which 1.3 million ha are permanent while the rest are seasonally inundated floodplains. There are repeated references to the crucial importance of fish and fish products to the nutrition of the people of Myanmar. Over the past few decades, inland fisheries resources have experienced increased pressure due to overfishing, use of destructive fishing gear/methods, pollution and environment changes. To make aquaculture sustainable and for conservation of aquatic biodiversity as well as to achieve nutritional security and improve rural livelihoods, fisheries resource enhancement and conservation measures have been adopted in Myanmar since 1967. This was initiated through a seed replenishing program to natural waters such as rivers, lakes, dams, rice fields and other watered areas. However, the institutional policy, legislative and financial environments under which enhancement and capture fisheries regimes exist are not conducive enough to the interests of the fishers. Strong tools for valuation of ecosystem goods and services, enabling governance arrangements and estimation of environmental flows are needed. Fishing communities need to be organized into strong co-management/participatory/community regimes to ensure that all stakeholders take part in the decision making process and the benefits accrued are shared equitably by all.

CR 9

The Philippine National Aquasilviculture Program (PNAP): Resource enhancement and sustainable aquaculture initiatives of the Bureau of Fisheries and Aquatic Resources (BFAR)

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The Philippine National Aquasilviculture Program or PNAP is a joint undertaking between the Bureau of Fisheries and Aquatic Resources (BFAR) and the Commission on Higher Education (CHED). It is a participatory program of the BFAR, with its Regional and Provincial Fishery Offices; CHED, and its participating State Universities and Colleges (SUCs); the Department of Natural Resources, with its Provincial Environment and Natural Resources Office (PENRO) and City Environment and Natural Resources Office (CENRO); and the Local Government Units (LGUs) as it is geared towards resource enhancement and sustainable fisheries development. The program covering fifteen (15) coastal regions of the country entails provisions of fisheries livelihood, food security and poverty alleviation.

The primary beneficiaries of the resource rehabilitation and protection and aquasilviculture projects are the fisherfolk of the coastal community, while that of the community-based multi-species hatcheries are the participating SUCs. The three (3) project components of PNAP are presented and discussed in the paper highlighting a) resource rehabilitation and protection; b) aquasilviculture; and c) establishment of community-based multi-species hatcheries in the implementing SUCs countrywide.

CR 10

Current Status of Aquaculture in Singapore

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Singapore is a small country state with a demographic profile of over 5 million in population. With limited land for agricultural purposes and sea space available for fish farming, Singapore depends heavily on importation of fresh seafood. Even so, Singapore has a small but thriving and increasingly important food fish farming industry which accounts for about 6% of local food fish consumption.

The main bulk of local food fish production comes from coastal farming in floating net cages along the northern coast of Singapore. Popular species of marine food fish cultured include seabass, pompano, groupers, mullets and milkfish. There are also a few land-based fish farms culturing species like tilapia, marble goby and snakehead.

The ornamental fish farming industry is concentrated mainly in Agro technology parks and there are about 75 fish farms producing ornamental fishes with an approximate value of \$ 76.7 million that is exported to over 80 countries.

The Agri-Food & Veterinary Authority of Singapore (AVA) is the national authority for aquaculture development in Singapore and manages aquaculture farms through the issuance of fish farming licenses. For marine food fish farms, the farm licensee has to abide by good farm management guidelines to maintain the farm in good condition and ensure that the farm does not engage in activities that would impact the farming environment. For land-based farms, there are also guidelines that address infrastructure layout, farming system and water treatment facilities. The latter requires

that sedimentation ponds, reservoir ponds/tanks, supply/drainage systems and trade effluent treatment plant are included in the farm set-up.

There are several challenges and issues faced by the aquaculture industry in Singapore. One of these is the consistent supply of good quality fish fry as farmers have to source for fish fry from overseas sources that may not be consistent or readily available. Issues of fish health and farm management are other challenges faced by our fish farms. These factors affect farm productivity and the sustainability of farming operations.

The AVA has established the Marine Aquaculture Centre (MAC) on St. John's Island to address the needs of aquaculture development for Singapore through fish reproduction and development of seed production as well as large-scale fish farming technology. At present, the fish reproduction technology research work involves closing the reproductive cycles of key marine food fish species and also fry production at a commercial scale level. Closing the reproductive cycle will help reduce reliance on imported fry. Good quality brooders are selected, maintained and bred to produce quality fry, which would translate to better growth performances and shorter culture period. This, together with good farm management practices, will optimize the usage of fish feeds during the culture cycle.

To fill the gap in production and supply of good quality fish seeds for local fish farms, AVA shares information on hatchery technology development with local commercial hatcheries.

The AVA collaborates with research institutes and local fish farms in the development of vaccines to boost the survival rate of fish fry and fingerlings. This will improve survivability, thus increase the production of the farms and reduce the reliance on prophylactic drugs which may have negative consequences with prolonged use.

The AVA also renders technical assistance to the farmers to formulate viable production plans to improve production. By leveraging on the use of technology and good farm practices, such as implementation of fish health, fish nutrition and feeding protocols, it is possible to reduce production costs

and improve productivity. The introduction of the Good Aquaculture Practice scheme for food fish farming will help improve the standards of the local aquaculture industry and sustainability through responsible management practices.

CR11

Milkfish: new choice for aquaculture in Thailand

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Milkfish is an economically important fish cultured in many countries in Asia. In Thailand, milkfish culture has not been given much attention and is not as developed as in the other Asian countries because the farmers preferred to grow shrimps and other high value fishes in the past. Nowadays, environmental changes and degradation can affect water resources as well as the important aquaculture species that thrive in them hence the Thai Department of Fisheries recognizes the importance of developing aquaculture that is environment-friendly. This includes milkfish in particular because milkfish meat tastes good, easy to manage on farm, grows rapidly and can be grown in sea water, brackish or even fresh water. Milkfish farming is a low cost operation because milkfish feeds mainly on algae and organic matter and these are natural food produced from other types of aquaculture activities. Milkfish can therefore be co-cultured with other species and are capable of reducing the amount of organic material from the process of aquaculture before entering the environment. In 2002, milkfish was first bred successfully through hormone injection and later broodstock mated naturally in Thailand. At present, production of the 1-inch milkfish has reached 1,000,000 per year. The culture sites are in the southern and eastern parts of the country, in brackish and saline areas. Culture methods are either monoculture or polyculture with other species such as shrimp, mussel, etc. Milkfish culture in reservoirs last from 6 to 12 months when fish size is about 500 g or two pieces to a kg and the price is about 50 baht/kg. On the other hand, milkfish that are 600-1,000 g can sell at 65-90 baht/kg. Apart from culture, processing as well as marketing of milkfish has also started in Thailand. Training on milkfish processing is being conducted at least two times a year. As for the marketing

initiatives, there is a move for milkfish to be declared the symbol of Prachuap Khiri Khan Province since it was here that the fish was first found naturally in Thailand. Milkfish will also be promoted in the festivals throughout the country. Although found promising, some problems in the Thai milkfish industry are also recognized. Such issues notwithstanding, the Thai Department of Fisheries is coming up with guidelines for milkfish aquaculture as it is optimistic that this commodity shall open the doors to a new alternative economy in Thailand.

CR 12
**Good Aquaculture Practice (VietGAP) – one of the solutions
towards sustainable aquaculture development in Vietnam**

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Consequent to the rapidly developing Vietnam shrimp (black tiger shrimp and white leg shrimp) and catfish industries, two major exported fisheries commodities in the last three decades, Vietnam aquaculture is facing problems on disease outbreak. Moreover, consumers nowadays are likely concerned on how the products are produce, and how the animal's health has been managed instead of how the diseased animal is treated. Hence, the main objective of the paper is to focus on one of the solutions that can address the problems/issues toward sustainable aquaculture in Vietnam.

ABSTRACTS OF PLENARY PRESENTATION

PL1

Is small-hold tropical aquaculture in a genetic plunge towards extinction?

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Tropical shrimp aquaculture is in a disease-induced crisis of lost production. The response to this crisis currently focuses on microbiology and pathology, quarantine, and trans-boundary transfer of shrimp. Here I propose that the crisis also involves an interaction between shrimp genetics and various human interests including protection of intellectual property. Breeders of high-quality strains generally employ (and are encouraged to employ) "genetic locks" that generate inbreeding when broodstocks are "copied". Smaller hatcheries sell cheap, copied, inbred shrimp to farmers, and farmers lose their crops to disease. The joint behavior of breeders, hatcheries and farmers causes inbreeding to accumulate in tropical regions.

The depressive effect of inbreeding on disease resistance is exceptionally strong in shrimp (published field and experimental data re-analysed here). Inbreeding increases the severity and frequency of disease through a variety of mechanisms. We have relatively few, marker-based estimates of accumulated inbreeding in any non-pedigreed shrimp aquaculture system. Simulation shows, however, that locked PLs can be distinguished from copies in broodstocks and farm ponds, given appropriate analysis of genetic markers.

Culture of stocks certified to be free of specified pathogens (SPF stocks) is strongly recommended and only SPF stocks can now be legally imported into most jurisdictions. These recommendations are appropriate, beneficial and necessary. But insofar as they increase the value of proprietary genetic

strains, such regulations may also increase the likelihood of copying, and thus inbreeding at farm level and ever-increasing susceptibility to disease and climate stress.

The intellectual property value of disease-resistant strains will be extremely high and intellectual property rights are fundamental to science-based economic innovation. Breeders will, and must, continue to protect their genetic improvement programs with genetic locks, especially in regions where judicial sanctions are ineffective. The regulatory objective should be to encourage biosecurity and genetic progress while discouraging copying and consequent inbreeding.

The current consensus that inbreeding is unimportant may therefore be out of date. Inbreeding may be amplifying the severity of diseases including the major current threats: White Spot Syndrome Virus (WSSV), Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV) and Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Disease (AHPND). Continuing to ignore the interaction between inbreeding and disease may become a fatal error for tropical shrimp aquaculture.

PL 2

Rapid adaptation to a new environment: is it reversible?

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Accumulating evidence suggests rapid adaptation of fish populations when they are exposed to artificial hatchery environments. However, little is known if rapidly-adapted populations can readapt to their original, natural environment at the same rate. Here I introduce salmonid studies that addressed this issue, in the context of distinct rearing environments between hatchery and wild. We found very rapid adaptation of the hatchery population, in which reproductive success under a natural environment became much lower than that in the wild population after only a few generations of captive rearing. However, we did not find any sign of fitness recovery after one generation of natural rearing, suggesting that the rapid adaptation to the new environment was not reversible in our case. I discuss potential causes of the irreversible fitness reduction based on our recent study. Understanding the mechanism behind the rapid adaptation of fish to hatchery environments will help us figure out a better, nature-friendly, and hence, a sustainable means of hatchery operations for human welfare.

ABSTRACTS OF CONTRIBUTED PAPERS

CP 1
Assessment of Hump Head Wrasse, *Cheilinusundulatus*, Spawning Aggregations and Declaration of Marine Protected Area as Strategy for Enhancement of Wild Stocks

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Hump head wrasse, locally known as *mameng* or Napoleon fish, *Cheilinusundulatus*, is the largest living member of the family Labridae. It is slow growing but can grow to a maximum size exceeding 2 m and 190 kg. This species was the first commercially important coral reef food fish to be listed on Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II in 2004 because of its vulnerable status and the ongoing threat to its conservation from international trade. Like many coral reef fishes, the hump head wrasse, *Cheilinusundulatus*, aggregate in reef areas when they spawn and this spawning behavior makes them highly vulnerable to overfishing. A study on the spawning aggregations of this species was conducted in the municipalities of Sibutu and Sitangkai in the province of Tawi-Tawi. This was done by first conducting Key Informant Interviews (KII) with fishermen, mariculturists, and other stakeholders and Focus Group Discussions (FGD) with local government leaders (municipal and barangay levels), Fisheries and Aquatic Resources Management Council (FARMC) members, marine protected area (MPA) management board members, mariculturists, and exporters. Based on the results of the KII and FGDs, underwater visual census of juvenile and mature *mameng* populations were conducted to document spawning aggregation sites in fishing grounds in Sibutu and Sitangkai areas. Since there were no photo-documentation of actual spawning aggregations of *mameng* in the reef areas indirect measures were used. Result of the KFI and FGDs indicated that the Baligtang Reef in Sipangkot and TandoOwak is the major source of mature *mameng* that go there to spawn. Anecdotal accounts of bajau fishermen showed that Dungun Dungon, Baligtang Reef, TandoOwak and Tugalan are traditional fishing

grounds for *mameng* spawning aggregations. From the length and weight analysis of *mameng* species caught by hook and line and fish pot in the Baligtang Reef and in Sipangkot, the estimated length at maturity of this species has been found to be 25-35 cm. There were 134 individuals caught within this size range and so potentially they would be spawning soon. Another indirect proof used was the underwater documentation of juvenile hump head wrasse which were regularly observed and photographed in association with seagrass beds and branching coral reefs in Baligtang Reef in Sipangkot, Sitangkai. A gonadal study also indicated that the *mameng* caught in this area, depending on the season, had more mature and ripe gonads. These were the basis of declaring Spawning Aggregation Sites in Tando Owak and Dungun Dungun in Sibutu and Baligtang Reef, Sipangkot and Tugalan in Sitangkai. These were declared as marine protected areas through a local ordinance by the municipal Sangguniang Bayan of the two municipalities. Management and enforcement plans have been developed and Bantay Dagat members have been trained to protect the spawning aggregations and this strategy aims to protect the wild stocks of hump head wrasse. Protecting the spawners would ensure that there would be enough recruits and hence prevent recruitment overfishing in these two municipalities which are the centers of *mameng* mariculture in the province.

CP 2
SEAFDEC/AQD Stock enhancement initiatives:
Release strategies established

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SEAFDEC/AQD's Stock Enhancement Program started more than a decade ago with the first stock enhancement initiative on the mud crab *Scylla* spp. funded by the European Commission. This was followed by another stock enhancement program in 2005 as supported by the Government of Japan Trust Fund. In preparation for its implementation, a Regional Technical Consultation on Stock Enhancement of Species Under International Concern was convened in Iloilo City, Philippines in July 2005 to identify species for stock enhancement. During the meeting, seahorses *Hippocampus* spp., giant clam *Tridacna gigas*, abalone *Haliotis asinina*, and sea cucumbers *Holothuria* spp. were among the priority species for stock enhancement work. This paper will report release strategies that have been established for giant clam, abalone and mud crabs.

To ensure better survival of giant clams, these should be reared in ocean nurseries until escape size of 20 cm shell length (SL). In the wild, these should be placed in shallow reefs with 0.5-1.5 m deep water during low tide. Better growth was observed in giant clams reared in shallow waters with warmer temperatures (mean±SE 29.5±0.24°C, range 26-31°C).

Abalone should be released at a minimum size of 3 cm SL. These should be transported from the hatchery in PVC transport modules and acclimated on site prior to release to eliminate mortalities caused by transport stress. Transport modules should be placed on the release site allowing the abalone to move freely out of the modules into their natural habitat.

Hatchery-reared mud crabs need to be conditioned in ponds prior to release to increase chances of surviving in the wild. Higher recapture rates were obtained in crabs measuring 4.5 cm carapace width or bigger during release.

In all releases, it is important to tag the released stocks to separate them from their wild conspecifics. Numbered dymotapes were used for giant clams, diet tagging employed in abalone, and coded microwire tags in mud crabs. In stock enhancement, it is also important to consider security of the release area. Releases should be done in more secured habitats such as marine protected areas rather than in open access areas where fishing is uncontrolled.

CP 3
Stock Assessment of Christian crabs
(*Charybdis feriatus*, Linnaeus, 1758) in San Miguel Bay

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A project designed to assess the status of swimming crab fisheries in San Miguel Bay mainly focused on *Charybdis feriatus*, was undertaken from November 2011 to January 2013. The analytical length-based fish stock assessment was employed using the FAO ICLARM Stock Assessment Tools (version 1.2.2). A total of 7,679 crabs (3,612 *C. feriatus* and 4,067 *Portunus pelagicus*) were used for the length frequency analysis. The mean carapace width (CW) of *C. feriatus* was 12.50 cm and 11.20 cm for *P. pelagicus*. These values were higher than the reported maturity size in San Miguel Bay of 8.30 cm and 8.5 cm CW, respectively. About 15% and 14 % gravid females were harvested monthly for both species which may contribute to recruitment overfishing. Population parameters using FiSAT (version 3.2) showed that the exploitation rate (E) for *C. feriatus* and *P. pelagicus* exceeded the optimum exploitation rate ($E_{0.5}$), implying excessive fishing efforts and heavily exploited stocks. Size at which 50% of the species mature was 9.62 cm CW for *C. feriatus* and 10.53 cm CW for *P. pelagicus*. Doable options for resource conservation and management strategies were proposed and these were supported by local government units (LGUs), including the Integrated Fisheries and Aquatic Resource Management Council.

CP 4

Abalone Aquaculture for Stock Enhancement and Community Livelihood Project in Northern Palawan, Philippines

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One of the interventions to feed the poorest of the poor fisheries sector in the country is the provision of livelihood in the form of mariculture of high value marine species. In the Philippines, livelihood in rural areas is largely linked to resource depletion, hence it is wise not only to provide livelihood to the community but also to encourage them to conserve and enhance the resources. As part of the revised R&D program, the Western Philippines University partnered with non-government organizations (NGO) and existing projects to embark on a community-based environment-concerned livelihood project using hatchery-bred abalone, although top shell was also considered for stock enhancement. This is in an on-going project thus, preliminary phases such as abalone production and cage-based grow-out as well as subsequent project plans will be discussed. The objectives of this study were to: (a) share the experiences in implementing this project, (b) identify success and failure drivers of the project, (c) explain the conceptual framework for the MPA-based stock enhancement to be used in this project, and (d) give recommendations to improve the implementation and ensure the success of the project.

The following activities have thus far been conducted: (a) development of criteria for cage micro-site selection; (b) writing of proposal and provision of financial assistance for hatchery juvenile production through a partnership Memorandum of Agreement; (c) presentation of site survey results to beneficiaries and stake holders; (d) conduct of trainings on abalone grow -out culture for people's organizations (POs); (e)

development and improvement of the training module; (f) signing of conservation agreement; (g) giving of cage materials and juveniles to POs; (h) on-site coaching; and (i) partial monitoring. The next activities include improvement in juvenile production, conduct of researches on abalone nutrition, and development of market and value chain flow analysis. The conceptual framework for community-managed stock enhancement will follow that of the Department of Environment and Natural Resources Integrated Coastal Resources Management Project (DENR-ICRMP), of which the stock enhancement project is anchored on the management of marine protected areas or MPAs.

The steps in all the activities were documented and while the project was in progress, performance of the participants in training was measured, the training module was improved, the training approaches were revised according to needs, and the growth and survival of juvenile abalone were monitored. The problems identified were (a) low production of juveniles, (b) insufficient food for grow-out, (c) political squabbles, (d) social preparation, and (e) delay in implementation schedule. Recommendations to improve or resolve the problems encountered are also presented in this paper.

CP 5

Community-based Stocking of Abalone in Sagay Marine Reserve, Negros Occidental, Philippines

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Abalone (*Haliotis asinina*) or *kapinan* in the vernacular, is one of the high-priced catch among fishers in coastal communities in the Philippines. High buying prices compared with other fish catch motivated small-scale fishers to target abalones and caused its overfishing in Brgy Molocaboc, an island inhabited by more than 500 fishing households within the Sagay Marine Reserve (SMR). Stock enhancement initiatives in other countries showed that releases have the potential to yield substantial benefits. However, some results showed that actual social benefits in terms of yields, distribution of benefits and institutional sustainability are often not achieved. SEAFDEC/AQD, with support from the Government of Japan Trust Fund (GOJ-TF) 4 and TF5, has been implementing a community-based approach to stock enhancement in Brgy. Molocaboc to ensure that its goals and strategies are within the social milieu of local stakeholders. This approach integrates the biological and social dimensions of responsible stock enhancement.

This paper describes the activities and experiences in the on-going 7-year community-based tri-party collaboration model to implement stock enhancement in SMR. The collaboration involves stakeholders such as: (1) fishers and their households, (2) local government units (LGU) at the city and barangay level, and (3) SEAFDEC/AQD. Following social assessment surveys, community organizing, information dissemination and participatory promulgation of abalone catch size regulation to sustain the stocks, an abalone stock enhancement demonstration site was established in June 2011 in the coralline intertidal flats of Brgy. Molocaboc. The fishers protect the demonstration site, the LGU provides logistics and oversight, and SEAFDEC/AQD provides hatchery-bred abalone juveniles and technical guidance. The outcomes showed that the juveniles established, grew and spawned in the release site, together with wild stocks. The tri-party collaboration continues but the participation of key stakeholders and uptake

of stock enhancement process remain variable even if the stakeholders continue to obtain economic benefits through regulated partial harvest and sale of mature abalones. The social aspects of stock enhancement remain a challenge and its relationship with the values and motivations of fishing communities in the Philippines should be studied.

CP 6

Community-based stock enhancement for coastal socio-ecological restoration

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The reality of declining quality of coastal areas has been evident for many developing countries, especially in Southeast Asia. In the Philippines, rural coastal zones and estuaries are now being characterized by declining wild fisheries resources and degrading environment. This paper presents as an example the typical rural coastal town of New Washington, Aklan, Philippines and showcases how the concept of community-based shrimp stock enhancement can provide incentives to restore the environment and provide sustainable fishing livelihood in the area.

The New Washington Estuary (NWE) in northeast Panay Island, Philippines was a productive fishing ground that has been suffering from degenerating brackishwater fisheries and estuarine environment. Average daily catch decreased from 24 kg in 1970s to 0.7 kg at present. Shrimp fisheries, the most important livelihood, declined in quality and quantity. The highly-priced and once very abundant tiger shrimp *Penaeus monodon* was replaced with smaller-sized and lower-priced species like the *Metapenaeus ensis*. These can be attributed to the conversion of 95% of mangroves to culture ponds in the past 50 years and to the increase in fishing gears by more than 400% since the 1990s. The need is evident to reduce fishing structures and rehabilitate mangroves. However, these drastic changes directly affect fishers' livelihood. This study explores the prospects of *P. monodon* stock enhancement as "positive reinforcement" for the NWE rehabilitation. Number of gears per capita may have to be reduced but shrimp catches will

be relatively high-priced. Simulations show that fishers can increase income by 300% from their existing 35 pesos/gear/day. Campaigns on the importance of mangroves especially as shrimp habitat can encourage locals to reforest the estuary especially in abandoned ponds. With effective management, law enforcement, and sustained support from different sectors, shrimp stock enhancement can be a positive strategy in estuarine rehabilitation and livelihood sustainability in the NWE.

CP 7
BFAR-CHED Philippine National Aquasilviculture Program
(PNAP) in Bataan

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Bataan Peninsula State University (BPSU) was given the opportunity to implement the Philippine National Aquasilviculture Program (PNAP) in Bataan. The program aimed to (a) rehabilitate the denuded mangrove areas through replanting of destroyed mangrove resources, (b) establish 16 units of aquasilviculture techno- demo projects for the fisher folks to raise fishery species as their livelihood while caring for the planted mangroves, and (c) establish Community-Based Multi-Species Hatcheries to increase endemic fish species in the area.

BPSU accomplished the target of 183,300 mangroves planted with 85.96% survival a year after planting (for which the beneficiaries earned P1,035,452.50), established 16 units aquasilviculture projects for the livelihood of the beneficiaries (reported income was P303,279.40). The program also enabled the establishment of community-based multi-species hatcheries that already produced an estimated 1,030,502,400 mud crabs, blue crabs, red and Nile tilapia to increase their population in the area.

The program is expected to bear potential impacts on our environment and to the lives of the marginalized people of our community through the collaborative efforts of BFAR, CHED, BPSU, LGUs and the fisher folks.

CP 8

Marine Fish Hatchery: Development and Future Trends

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The basic procedures for producing marine fish fry in hatcheries developed for milkfish fry production nearly 3 decades ago are the basis of fry production systems for all other species of marine fish that are now reared in hatcheries in the Philippines and other Southeast Asian countries. These include large-scale microalgae production in outdoor tanks, feeding of appropriate sized rotifer grown on microalgae such as *Nannochloris* during the first feeding phase, and shifting to larger prey such as *Artemia* towards the latter stages of production.

In recent years, the increasing demand for high-value species such as groupers, sea bass, red snapper, and pompano in both the local and export markets has encouraged a number of marine fish hatcheries to produce fry of these species to supply the requirements of fish cage farmers. Techniques are modified using information from research institutions and multinational firms active in developing products and equipment to improve commercial production of these species. Larval feeds of appropriate sizes, forms and presentation for various larval stages incorporating essential nutrients, micronutrients, and feed stimulants are now available in the market. Disease in marine fish hatcheries have become common occurrences such that application of various chemotherapeutants, vaccines, and immunostimulants are now available and increasingly being applied in fish hatcheries. Technological developments in hatchery systems such as the use of recirculating systems, water pretreatment protocols (ozonation, microfiltration, UV light treatment) are also increasingly being adopted by commercial establishments.

A critical link between fry production and production of marketable fish is fingerling/juvenile production in nurseries. Fry are commonly grown in brackishwater fishponds to appropriate size for stocking in fish cages. Development of methods to improve growth through proper feeding and

nutrition, eliminate or reduce disease occurrence and parasite infestation, reduce cannibalism in cannibalistic species such as sea bass, grouper and snappers are active areas of research. Nursery production is integrated with fry production in large commercial facilities but is also done by small-scale fish farmers who have access to fry either from the wild or hatcheries. Commercial hatcheries adopt fingerling production from well-studied species in developed countries. Small-scale farmers however still rely on zooplanktons collected from the wild such as copepods, *Moina*, mysids, and trash fish as feed. Production is dependent on availability of feed sources and susceptibility to pathogens and parasites that come with the feed. It can be erratic since small-scale farmers are vulnerable to changes in climate and weather conditions.

Further technological developments in marine fish hatcheries will increasingly be led by commercial establishments and industries developing products like photobioreactor for microalgae, algal paste, or intensive systems for rotifer culture. Research institutions will however need to support the needs of the small-scale farmers and hatchery operators who may not be able to apply costly products from these companies by developing innovative simple techniques that can improve culture systems such as producing fry and fingerlings in mesocosm pond system, the appropriate use of probiotics as water stabilizer, and use of formulated feeds and production of zooplankton in ponds.

CP 9
Hatchery Management Techniques of Tiger-tail Seahorse,
Hippocampus comes

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Seahorse culture is being done throughout the world to meet the demand of global trade and reduce the pressure from overexploitation. Development of culture techniques for seed production of seahorses is one of the most effective measures to avoid such anthropological repercussions on the wild stocks. It is currently being studied in SEAFDEC/AQD with the aim to produce seed for stock release and protect this internationally threatened and overexploited species in Southeast Asia. The present study addresses the main breakthroughs in seahorse breeding and nursery rearing. So far, we have defined water and feeding management schemes that resulted in higher survival and growth rates in new-born seahorse.

UV-treated sea water brought significantly better growth during the 30 days culture (41.4 ± 0.5 mm, 0.23 ± 0.00 g in stretched height and weight, respectively) than in chlorinated (33.8 ± 1.4 mm, 0.16 ± 0.00 g) or sand-filtered (32.8 ± 0.1 mm, 0.16 ± 0.00 g) sea water in *Hippocampus comes* during the 30 days culture after birth. Survival also increased significantly in UV-treated ($65.6 \pm 1.1\%$) than in sand-filtered sea water ($41.1 \pm 1.9\%$), followed by chlorinated ($62.2 \pm 4.0\%$) sea water. Seahorses fed 30 ppm formalin-treated copepods ($95.3 \pm 1.8\%$) showed significantly higher survival ($p < 0.05$) than those fed untreated copepods ($78.7 \pm 5.5\%$) on day 8. On day 15, survival was $78.7 \pm 9.68\%$ in seahorses fed formalin-treated copepods and 0% in those fed untreated copepods. By day 30, survival of seahorses fed formalin-treated copepods was $64.7 \pm 9.82\%$. Thus, survival and growth of newborn seahorses were proven to significantly improve in UV-treated

water, and formalin-treated food organisms also increased survival markedly.

The present paper includes discussion on broodstock selection and management, larval rearing, and tank design. Concern towards ensuring sustainable supply of desirable food organisms and maintenance of suitable water quality in order to maintain maximum efficiency in the management of the seahorse hatchery is highlighted.

CP 10

Post Larval Rearing Strategies in Sandfish (*Holothuria scabra*) Culture

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Various post larval rearing methods were compared to determine which would give the most yield of newly settled (visible) juvenile stage (≥ 1 mm body length). Five types of post-larval rearing methods were tested: a) T1-planktonic diatom only (*Chaetoceros calcitrans*, Cc), b) T2-benthic diatom *Navicula* as biofilm and concentrate, c) T3- *Navicula* as biofilm + Cc, d) T4-*Spirulina* as paste on settling plate + Cc, and e) T5- *Spirulina* as paste on settling plates + *Navicula* concentrate. An experiment was run in small scale using 3-li aquaria using a cohort of Day 14 (post-fertilization) sandfish larvae. Simultaneously, rearing was also done using T2, T3 and T4 in medium scale using 30-li aquaria to determine how the conventional method (T2) employed in a pilot sea cucumber hatchery in the Central Philippines compared with T3, the method observed in Vietnam or with T4, a hybrid method. Visible post-settled juveniles were counted weekly for the next 3 weeks and expressed as percentage yield. After 3 days of rearing, transparent but visible early settled juveniles were observed. Mean % juvenile yield in Week 1 was highest in T1 ($17\% \pm 1.3$) followed by T3 ($14\% \pm 1.6$) in small scale containers. Yield increased and peaked in Week 2 especially for rearing methods with *Navicula* while those in T1 and T2 declined dramatically by Week 3. In the 30-li scale, T5 had consistently given highest mean yield until Week 3 ($12\% \pm 11.2$). The mean juvenile yield on Weeks 2-3 were better than the usual 2% average for this stage or from the 2.5% “benchmark” based on experiences in the Philippine and Vietnam.

CP11

Updates on the Seed Production of Mud Crab

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Widespread interest in mud crab species is increasing as these are highly priced both in domestic and export markets. Among the three mud crab species commonly found in the Philippines, it is the *Scylla serrata* that is preferred by farmers because it is larger and less aggressive.. Likewise, *S. serrata* is the most widely distributed species in the Indo-west Pacific region. The other two species are *S. olivacea* and *S. tranquebarica*.

Hatchery-produced *S. serrata* seedstocks are presently being used by some crab farmers in their culture operations. In the hatchery phase, co-feeding of mud crab larvae with shrimp formulated diets and natural food was found to lessen the occurrence of molt death syndrome, one of the major problems in seed production. Larvae given 25% formulated diet (FD) + 75% natural food (or NF; rotifers and *Artemia*) and 50% FD + 50% NF showed better performance than those larvae fed 100% FD, 100% NF or 75% FD + 25% NF, indicating that the utilization of natural food, especially the expensive *Artemia*, can be reduced. Since the early crab instar (C) produced in the hatchery needs to be grown further before stocking in the grow-out ponds, two phases of nursery culture have been developed. C₁₋₂ are grown to 1.5 cm carapace width (CW) size in the first phase and further grown to 3.5 cm CW in the second phase. Nursery rearing is done in net cages installed in ponds for easy retrieval. A combination of mussel or trash fish and formulated diet is used as feed.

Domestication of the mud crab *S. serrata* as a prerequisite to selective breeding has been done at SEAFDEC/AQD. Likewise, the criteria for determining the quality of newly hatched zoeae (for stocking in the hatchery) were defined. Newly hatched zoeae were subjected to starvation and stress test using formalin. Starvation failed to elicit responses that could significantly differentiate the good from poor quality larvae hence this parameter was noted as unsuitable for larval quality evaluation. Based on a

three-year data, the formalin stress test gave mean cumulative mortalities of 2.38 ± 0.32 , 8.24 ± 0.88 , 20 ± 1.58 , and 43.74 ± 2.39 in good quality larvae while mortalities of 22.93 ± 4.19 , 63.68 ± 7.17 , 84.29 ± 3.88 and 97.65 ± 1.06 were recorded for poor quality larvae at 0 (control), 20, 30 and 40 ppm formalin, respectively. As formalin level increased, cumulative larval mortality also increased regardless of the quality of the larvae. Formalin stress test proved to be a reliable method to determine whether a batch of newly hatched zoeae was good or otherwise.

CP 12

Induced Breeding of Giant Trevally, *maliputo* (*Caranx ignobilis*)

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The giant trevally, *maliputo* (*Caranx ignobilis*), a highly prized and most popular indigenous migratory fish in Taal Lake, Batangas, Philippines, was induced to spawn using various hormones (to assess its efficacy on spawning performance) and later, different feeding regimes in the larval rearing of the species were evaluated. Sexually mature breeders, 5 to 7 years old with at least 0.5 mm oocyte diameter and 60% of ova at GVM stage were injected intramuscularly, in two doses, with: (a) 1,000 IU human chorionic gonadotrophin (HCG); (b) 100 µg luteinizing hormone releasing hormone analogue (LHRHa); and (c) 5 mg carp pituitary extract (CPE), at five breeders per hormone treatment. Uninjected fish served as the control. Treated fish were released and allowed to spawn spontaneously in 40-ton (5m diameter) circular tanks.

Successful spawning was achieved during the months of March to July (28-30 ppt salinity; 27.6-29.25°C). *Maliputo* eggs are pelagic, clear and spherical, with a single oil globule and mean diameter of 0.8 mm. Ovulation period was 24-36.5 hours after 2nd injection in HCG-treated fish and 25-52 hours for LHRHa-injected fish. Only one of the CPE-treated fish spawned after 27 hours but eggs were not fertilized. Uninjected control fish did not spawn. Eggs were hatched in 11-13 hours in HCG treatment and 11-17 hours in LHRHa. Mean number of spawned eggs (3,500-4,000 eggs•gram⁻¹) was higher in HCG treatment (223,068 eggs•kg⁻¹ breeder at 58.27g•kg⁻¹ breeder) than LHRHa (176,524 eggs•kg⁻¹ breeder at 50.44 g•kg⁻¹ breeder). Fertilization and hatching rates were both higher in LHRHa (60.88% and 71.07%, respectively), than HCG treatment (30.53% and 43.06%). Mean

number of produced larvae was higher in LHRHa treatment (56,040 larvae•kg⁻¹ breeder) compared to HCG-treated fish (41,547 larvae•kg⁻¹ breeder).

Hatched larvae (1.6 mm mean length) reared for 30 days in 3m x 3m concrete tanks using the standard protocol for marine finfish hatchery attained a maximum survival of 4.47%. Complete metamorphosis was observed after 26-28 days (8.1 mm mean length). Successful larval rearing was attained using greenwater (*Nannochloropsis sp.*) technology fed with live food (*Brachionus sp.* and *Artemia salina*). Critical periods were days 1-7 and days 19-22 when heavy mortalities were observed.

Being the first recorded spawning in captivity of *Caranx ignobilis* in the Philippines, the results of this study provides important baseline data and is a major step towards the development of a hatchery technology for *maliputo* in the country as well as for seed enhancement of its natural habitat. The project has provided 400,000 *maliputo* larvae to private hatcheries for larval rearing trials while 100,000 larvae were seeded in Balayan Bay and 5,000 fingerlings released in Taal Lake.

CP 13

Seed production of the blue swimming crab *Portunuspelagicus*

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The blue swimming crab, *Portunuspelagicus*, is becoming a commercially important species in the Philippines. The expanding export market for crabs has led to intensified collection and has threatened the wild stocks. This decline has prompted the need for proper management of the remaining resources, and interest in the establishment of hatchery facilities to produce crablets for reseeded and aquaculture.

This paper presents the production for *P. pelagicus* seedstock at the Guiuan Marine Fisheries Development Center. Experiments to improve larval rearing were conducted as well. For seed production, zoea larvae were taken from wild-caught berried crabs hatched in 100-L circular drums filled with sand-filtered seawater (32-34 ppt, 28-30°C). Zoea larvae were stocked at 100 zoea L⁻¹ in rectangular tanks and fed rotifers at 30 ind ml⁻¹ for the first 4 days. Newly-hatched *Artemia* were given at 1-2 ind ml⁻¹ at zoea 3, and increased to 5 ind ml⁻¹ at zoea 4 to the megalopa stage. *Chlorella* sp. is maintained in the rearing tanks at 50,000 cells ml⁻¹ as food for rotifers and for water conditioning. Water exchange was done daily at 30-50%, except for the first 5 days of rearing. The development from zoea 1 to megalopa and megalopa to the first crab instar took 10-12 and 4-6 days, respectively. Longer larval development was observed at lower temperature (<26°C). Cannibalism and deteriorating water quality were identified as major causes of mortality. Survival of zoea 1 to megalopa was higher in chlorinated seawater (7.5±2.58%) compared to UV-treated (6.5±1.73%) and sand-

filtered ($4.0 \pm 2.58\%$) seawater. Trials involving the use of different tank background colors showed that the survival of larvae was highest in black tanks ($9.0 \pm 1.00\%$) as compared to those white tanks ($1.5 \pm 0.58\%$).

In nursery rearing, megalopae were stocked at $1-2 \text{ ind ml}^{-1}$ in wide tanks or concrete pond. Strategies to reduce cannibalism was done by providing shelters and sand substrate ($>10 \text{ cm}$). As soon as the megalopa molted to crab instars, they were given minced fish, shell meat, *Acetes* and formulated crab feeds twice daily *ad libitum*. After 21 days, crablets were collected manually after partially draining the water in the concrete pond. The crablets produced were released in identified fish sanctuaries and marine protected areas region-wide for resource enhancement and for aquaculture research purposes.

CP 14

Potential genetic impacts of hatchery-based resource enhancement

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The global population according to the United States Census Bureau has reached 7 billion as of October 2013. This continuous growth in human population will continue to make tremendous pressure on food production. The demand for fish as source of good protein is no exception. In 2011 total capture fisheries supplied 90.4 million tons of food and total aquaculture provided 63.6 million tons. While aquaculture production has increased dramatically, more than 50% of fishery production still depends on capture fisheries. Overexploitation of wild fish stocks has become one of the biggest problems in global fisheries. Stock enhancement has become a potential viable strategy for marine fisheries in danger of collapse. With the tremendous progress made in the breeding and larval rearing techniques of marine species, hatchery-based stock enhancement is now operated in many stock enhancement programs. However, many questions are raised in the use of hatchery-reared fish in stock enhancement. This paper will discuss genetic considerations in stock enhancement in developing countries.

CP 15

Marker-aided Genetic Stock Management: Prospects in Philippine Aquatic Biodiversity Conservation and Aquaculture

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With the advent of DNA marker-based technologies and applications, genetic stock assessment incorporating molecular marker information has become an important tool in managing resources both for aquaculture and stock enhancement. Local initiatives toward this end have been undertaken by several research and academic agencies particularly those with access to advanced molecular genetic laboratory facilities both in the Philippines and in collaborating foreign institutions. Funds coming from the Philippine Department of Science and Technology and/or international research grants have supported work on commercially valuable species such as tilapia, shrimp, mud crabs, abalone, milkfish and some high value marine fishes with a view of utilizing, and in the process, demonstrating the significance of more scientific micro-level assessment of stocks. Information drawn from marker-aided genetic stock evaluation can contribute to a better understanding of the impact of how proper stock management can be more effectively achieved and how this method can gradually translate to improved yields both from culture and fisheries. This paper covers a review of the status of this technology as applied to on-going fish conservation and aquaculture production efforts in the Philippines.

CP 16
Feed formulation for sustainable aquaculture

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As aquaculture production of tropical fish and crustacean species becomes more intensified, practical diets need to be formulated to be cost-effective and environment-friendly. Ingredients should be included to satisfy the nutrient requirements of the animal, promote optimal fish growth, and boost the income of small-scale farmers and commercial producers with minimal impacts to surrounding environment. Feed formulation for sustainable aquaculture should aim at increasing the performance of the aquaculture system and profitability, increasing disease resistance of the animals, increasing the attractability, palatability, and digestibility of practical diets, and environmental protection through sound feeding management and good aquaculture practices. More vigorous research and development efforts need to be supported to generate feed technologies that will ensure a steady and reliable supply of safe and quality fish to the public while preserving the environment.

CP 17

Potential of cowpea *Vigna unguiculata* meal as alternative plant protein source in diets for giant freshwater prawn *Macrobrachium rosenbergii* (de Man)

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Giant freshwater prawn, *Macrobrachium rosenbergii* (de Man) is considered a promising alternative to lobster and black tiger shrimp because of its high market value. World production of this species rose to more than 200,000 tons in 2002 and this is one of the factors that caused increase in the demand for fish meal. Increases in its prices and the tendency of fish meal to deteriorate environmental waters could be the major hindrance in the profitability of prawn operation. In order to bring down feed costs and nutrient inputs to the environment, use of alternative plant-based protein sources is desirable.

Growth trials were conducted to evaluate cowpea *Vigna unguiculata* meal as a partial replacement for fish meal in diets for giant freshwater prawn. Five isonitrogenous (35% crude protein) and isocaloric (346-350 kcal/100 g diet) diets were formulated where sardine fish meal was replaced by cowpea meal at varying levels (0, 15, 30, 45 and 60%). Trials compared growth and survival of prawns under laboratory and lake-based conditions. Cowpea meal-based diets were found to be acceptable up to 45% replacement level with no adverse effect on growth performance. The nitrogen and phosphorus excretion of prawns fed experimental diets were also determined.

CP 18
**Application of the United States Soybean Export Council
Program's Low Volume, High Density Cage Aquaculture
Technologies and Soy-Optimized Floating Feeds in Fish Cage
Culture**

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The United States Soybean Export Council (USSEC) is a non-profit, international marketing organization that is supported directly by United States soybean farmers and the US government to highlight both the benefits of US soybeans and generally promote its use. USSEC's role is to facilitate knowledge transfer about soy and to help increase the technical knowledge and range of soybean product use in the global market.

The Soy-In-Aquaculture (SIA) program introduced the USSEC Low Volume High Density (LVHD) cage culture production methodology to Southeast Asia in 2002. This cage aquaculture production technology was developed by the USSEC program under Dr. Michael Cremer in China with the aims of maximizing farmer profit, improving productivity, reducing feed conversion ratios (FCR) and limiting environmental degradation. The highlights of this system are optimizing cage production through maximum cage volumes and harvest biomass in relation to the carrying capacity of aquaculture areas. This is done also through proper cage positioning, use of high quality extruded floating feeds and strict feed management.

The LVHD cage culture production technology has been proven successful in China and other Southeast Asian nations. The focus of this cage culture technology is to maximize cage production through the use of smaller cages

with maximum sizes of 2x2x1 m (4 m³) for freshwater and 3x3x3 m (27 m³) for brackish and marine areas and setting a maximum cage biomass of 100 – 250 kg/m³ for freshwater and 50 – 75 kg/m³ for marine water at harvest.

One of the highlights of this system is the use of high quality, nutritionally complete, extruded floating feeds. Most fish species will accept a floating feed with minimal training, and the farmer also needs to be trained on how to use a floating feed, including the use of a feed enclosure to prevent feed from exiting the cage. The program developed a feeding management called the “90% satiation” technique that uses fish response to basal feeding rate and does not rely on a set feeding table or attempt to feed to satiation every day (which would waste feed and increase FCR).

Fish farmers that have adopted some or all of the suggested technological approaches have recognized its benefits compared to traditional commercial culture methods. The farms that have adopted the use of maximum cage volumes, target biomass densities, proper cage positioning, use of high quality extruded floating feeds and 90% satiation feed management, have improved production and realized better profit margins.

CP 19
**Good Aquaculture Practices (GAqP): Setting directions for
harmonized regional standards - the Philippine experience**

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A milestone process on how Good Aquaculture Practices (GAqP) emanates in Philippine aquaculture and its integration to the ASEAN harmonized standardization efforts is discussed in the paper. The management model, value chain and draft Philippine National Standard of the GAqP code are presented and evaluated as to its impact to trade and marketing, socioeconomic considerations, food safety and technology.

CP 20
Responsible shrimp culture through ecological approaches

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Aquaculture is the fastest growing food-producing sector. Aquaculture is the farming of aquatic organisms, like crustaceans, fish, molluscs and plants. Farming of aquatic organisms is usually done in earthen ponds with some intervention in the rearing process to enhance production. Some of the processes that enhance production are pond preparation, regular stocking, feeding, and use of probiotics and other chemicals to improve soil and water quality and improve shrimp growth and immunity against diseases. The long range effect of the use of probiotics and other chemicals on the environment and on shrimp is unknown. Despite the various inputs, diseases continue to plague the industry, which could be due to deteriorating environmental conditions that expose shrimp to stressors and make them susceptible to infection. Furthermore, chemicals and nutrients from aquaculture may affect biodiversity of the receiving environment. This paper describes responsible shrimp culture through ecological approaches to improve environmental conditions.

Cross sectional, longitudinal and tank studies done identified the use of the greenwater culture system and the presence of mangrove as some of the ecological approaches to improve environmental conditions. Water quality, including microflora, may be improved through the use of molasses, abundant phytoplankton growth and liming. Other practices are crop rotation, biofloc technology, and aquaponics. The advantages and disadvantages as well as the mechanisms behind these approaches will be discussed.

CP 21

Utilization of Sensors and SMS Technology to Remotely Monitor the Level of Dissolve Oxygen, Salinity and Temperature of Fishponds

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Due to the occurrence of fish kills in various fish producing areas in our country, millions of pesos, employment and livelihood opportunities for local fisherfolk were lost. Bataan Peninsula State University (BPSU) collaborated with the Central Luzon Association of Small- Scale Aquaculture and tried to devise strategies to address the said problem and to prevent further losses in income as well as business opportunities apart from increasing fish yield from sustainable farming operations.

The most probable reason for a fish kill is the loss of dissolved oxygen (DO) in the water, decline or increase in salinity levels and a sudden increase in temperature, which are the effect of massive rainfall, flooding or high tide, too much ammonia due to decomposing organic matter and even high temperature levels during summer.

Hence in this study, the use of radio frequencies and installation of sensors in different areas of the fishpond at various depths were tried to remotely monitor the levels of dissolved oxygen, salinity and temperature of the water. Once these parameters reach a critical level, the installed system with specific program will send an alarm through radio frequencies via SMS technology to the cellular/mobile phone of the caretaker or the fishpond operator. Upon receiving the alarm, the fishpond caretaker will then be able to adjust the levels of dissolved oxygen, salinity and temperature of the water by remotely switching on the air compressor or the electric water pump using their cellular/ mobile phone, thus preventing losses due to fish kills.

CP 22
**Reaching the poor through aquaculture: the case of technology
adoption in rural communities at west central Philippines**

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Aquaculture is promoted to provide food security and poverty alleviation in developing countries. This study examines the socio-economic impact of aquaculture technologies extended to calamity stricken rural communities in Nueva Valencia, Guimaras, representing the marine water fishery and in Dumarao, Capiz, representing the inland freshwater fishery at west central Philippines. The adoption pathway employed in both sites was community-based and participatory. A survey was conducted among cooperators and non-cooperators, randomly selected in equal numbers from the two sites with 60 respondents per site using a pre-tested interview schedule.

Results showed that aquaculture is an acceptable technology both for cooperators and non-cooperators. The venture is a profitable business either done individually or by association if managed properly. Milkfish cage culture, however, needs big capital hence technology adoption among local fishers (Guimaras) is limited. In contrast, tilapia cage culture enables small farmers/fishers in Dumarao to venture on their own. Dumarao growers were able to innovate using local materials like bamboo poles to make their cages afloat instead of drums or plastic containers as buoys. There were, however, environmental, technological and institutional issues deterring technology adoption in both sites. Climate change and institutional issues were the more prevalent concerns of Dumarao growers. The technological issues like fluctuating market price, cost of feeds, and fry supply were more enunciated in Guimaras.

CP 23
**The Economics of Aquaculture Development: Sustainability and
Food Security**

Maripaz Perez

CP24

The Importance of Mangroves to Capture and Culture Fisheries

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Mangroves are widely acknowledged as critical habitats which provide invaluable benefits of local, national and global interest (Table 1).

Table 1. Benefits from mangroves (Field, 1995)

Local Communities	National Interests	Global Interests
Shelter	Timber production	Conservation
Construction timber	Charcoal production	Education
Firewood	Fishing industry	Indication of climate
Food	Shrimp and crab industries	change
Income from fishing, shrimp culture, and wood gathering	Water quality management	Preservation of biodiversity
Income from cottage industries	Mangrove silviculture	
Medicine	Mixed shrimp farms-mangrove forestry enterprises	
Fodder for animals	Wetland habitat creation	
Protection from storm damage and river bank erosion	Recreation	
	Tourism	
	Education	
	Coastal and estuary protection	

The wide array of ecohydrographic services of mangroves, e.g., coastal protection from storms and tsunamis, nutrient recycling, erosion control, sediment trapping, wildlife habitat, fish/invertebrate nurseries, and fishery and forestry products have a total value of US\$10,000-36,000/ha/yr mostly for coastal protection (Table 2).

Table 2. Mangrove valuation from various studies.

Sources	PhP/ha/year	USD/ha/year
Value of Total Goods and Services		
Costanza et al, 1997	495,000/ha/year	9,900
Spurgeon and Roxburgh, 2005 American Samoa	520,000	10,400 (104,000/sq km/year)
Sathirathai and Barbier, 2001 Thailand	1.8-17.5 million	27,000-35,000 (2.7-3.5 million/sq km/year)
Wells et al, 2006	20-45 million	200,000-900,000
Value of Individual Goods and Services		
Ronnback, 1999 - Fisheries - Wood products (Malaysia)	45,000-620,000	900- 12,400 11,561
Ruitenbeek, 1992 - Erosion control	3,000 household/year	600/household/year
Lal, 1990 - Fiji	264,000	5,280
Cabrera et al, 1998 - Mexico	59,500	1,190
Costanza et al, 1997	420,750	8,414

A more recent study gives a total value of around \$14,000-16,000/ha, of which 55-67% is for coastal protection (Table 3), particularly important considering more than 20 typhoons that hit the Philippines yearly. Although the fisheries maintenance value of mangroves is only \$708-987/ha compared to \$8,966-10,821/ha for coastal protection, it is critical to the survival of sustenance fishers who are often landless and marginalized, with no other means of livelihood.

Table 3. Valuation of mangrove services (Barbier et al, 2011)

Services	Value (USD/ha/year)
Raw materials and food	484-485
Coastal protection	8,966-10,821
Erosion control	3,679
Maintenance and fisheries	708-987
Carbon sequestration	30-50
Total	14,166-16,142

More than 2/3 of global fish and shellfish harvests have been linked directly to estuarine nurseries, and mangrove-related species contribute 30% of fish and

100% of prawn catches in Southeast Asia. Many studies showed a significant statistical relationship between catches of fish or shrimp and mangrove area or length of mangrove-lined coastlines. Three factors are associated with the nursery function of mangroves, accounting for the high number of juvenile fish and shrimps: (a) high abundance of food, (b) lower predation pressure due to shallow-water micro-habitats, higher turbidity and reduced visibility compared to unvegetated nearby habitats, and (c) complex physical structure, e.g., prop and aerial roots. These factors can act in synergy to constitute directly and/or indirectly the nursery-role of mangroves, enhancing density, growth, and survival of juvenile fish and invertebrates. Mangrove structural complexity provides shade from the canopy, high turbidity, and fine sediments that reduce the rate of predator-prey encounters.

Mangrove Area, 4:1 Paradigm

Globally, mangroves cover 14-15 million ha spread over some 120 countries, showing a drastic decline worldwide within the last few decades from 18 million ha in the early to mid-1990s.

The major threats to mangroves are overharvesting for fuelwood and construction, and conversion to resorts, housing projects, agriculture and aquaculture. In particular, shrimp pond culture accounted for 38% of global loss of more than a third of mangroves in the 1980s-1990s. The decline of Philippine mangroves from ~500,000 ha in 1918 to ~241,000 ha as of 2010 may be traced to overexploitation by coastal dwellers, conversion to agriculture, salt beds and settlements, but mainly to brackishwater pond construction for fish/shrimp culture. Both mangroves and aquaculture provide food security, but the former offer many more services and greater equity compared to ponds (Table 4). Brackishwater ponds have increased almost fourfold from 61,000 ha in 1940 to 239,000 ha at present, giving a ~1 mangrove: 1 culture pond ratio (Table 4), a drastic decline from the 7.4:1 ratio before the fishpond boom of the 1940s-60s. It is also way below a 4:1 ratio recommended by ecologists for ecological sustainability.

Table 4. Goods and services from mangroves compared to brackishwater ponds.

COMPARISON OF MANGROVES VS AQUACULTURE PONDS	
Mangroves	Fish/shrimp Ponds
<ul style="list-style-type: none"> • Fisheries products: food security • Storm protection • Waste disposal • Flood regulation/ erosion control • Forestry products 	<ul style="list-style-type: none"> • Fisheries/food production: food security (milkfish, tilapia), luxury crops (shrimps, crabs)
<p>Total value: PhP0.5–20 million/ha/yr</p> <p>Sectors - small scale-fishers & families; coastal populations</p>	<p>Total value: PhP90,000-3 million/ha/yr</p> <p>Sectors - b'water pond operators; aquaculture industries</p>

Mangrove-Friendly Aquaculture

As the development of pond culture is intertwined with the fate of mangrove forests, there is a need to make pond culture more environmentally sustainable and mangrove-friendly. Mangrove-Friendly Aquaculture (MFA) technology may be defined on two levels: a) silvofisheries or aquasilviculture where the low-density culture of crabs, shrimp and fish is integrated with mangroves, and b) high-density culture of fish/shrimp whose effluents are filtered by adjacent by separate mangrove stands. Based on the first model, the SEAFDEC Aquaculture Department conducted a study to evaluate the effects of mud crab netpen systems on mangrove macroflora, and the replacement of dietary trash fish with low-cost pellets. Results showed that incomplete, low-cost pellets can replace fish biomass requirement in mud crab diets, but that the presence of crabs resulted in fewer mangrove seedlings and saplings. Only minimal short-term impacts were observed on adult trees, but long-term (5-10 years or more) impacts need to be monitored. Economic analysis showed the viability of crab culture in mangrove pens using a combination of fish biomass and pellets to reduce the requirement for (low-value) fish, which is a food item of poor coastal communities.

In another study, effluents from a shrimp pond were made to pass through a natural mangrove stand; decreased nutrient levels (NH₃-N, NO₃-N, PO₄-P, sulfide) were reported within 6 hr after daytime draining into the mangroves, but only nitrate reduction was statistically significant. Based on nitrate loss (from intensive to semi-intensive shrimp densities), water volume drained, mangrove area, etc., calculations show that 1.8-5.4 ha of mangroves are required to remove nitrate wastes from one ha of shrimp pond. Longer nipa palm leaflets and faster mangrove seedling growth (but not mangrove biomass) of experimental mangroves suggest N uptake by the mangrove macroflora. Previous studies give a range of 3-9 ha of mangroves needed to treat nitrogen wastes from one ha of shrimp pond (Table 5). These figures approximate the earliest recommended ratio of 4: 1 (Saenger et al., 1986).

Table 5. Ratio of mangroves to culture ponds under different conditions.

Mangrove: Shrimp/Fish Pond Ratios		
Pond Ratio	Function	References
8.9:1 7.8:1	N filter: intensive shrimp culture P filter: intensive shrimp culture	Boonsong & Eiumnoh, 1995
7.2:1 21.7:1	N filter: intensive shrimp culture P filter: intensive shrimp culture	Robertson & Phillips, 1995
2.4:1 2.8:1	N filter: semi-intensive shrimp culture P filter: semi-intensive shrimp culture	Robertson & Phillips, 1995
6.4:1	N filter: semi-intensive shrimp culture	Kautsky et al., 1997
3.6-5.4:1	N filter: intensive shrimp culture	Primavera et al., 2007*
1.8-2.7:1	N filter: semi-intensive shrimp culture	Primavera et al., 2007*
4:1	Ecosystem health	Saenger et al., 1983**
7.4:1	Philippines: 450,000 ha mangroves (1920) 60,998 ha ponds (1940)	Primavera, 2000
1:1	Philippines: 247,360 ha mang. + (1994) 239,000 ha ponds	Primavera, 2000; NAMRIA, 2003

*Primavera JH, Altamirano JP, Lebata MJHL, delos Reyes Jr. AA, Pitogo CL. 2007. Mangroves and shrimp pond culture effluents in Aklan, Panay Is., central Philippines. Bull. Mar. Sci. 80: 795-804

**Saenger P, Hegerl EJ, Davie JDS. 1983. Global status of mangrove ecosystems. IUCN Commission on Ecology Papers No. 3. Gland, Switzerland

The use of mangrove filters reflects a major paradigm shift from the present practice of releasing untreated pond wastes to cleaning up before release, and will improve aquaculture sustainability. These ratios should be refined according to site hydrodynamics, whether nutrients are released to subtidal waterways or intertidal basin forests, etc. Therefore the aquaculture industry should conserve/rehabilitate mangroves as potential pond biofilters following protocols (e.g., non-use of antibiotics/ chemicals and prior sedimentation of effluents), in the process implementing legally mandated 20-/50-meter greenbelts. The 4:1 ratio will go even higher if the equally vital mangrove functions of coastal protection, fish/invertebrate nurseries, flood regulation and soil stabilization are added. The devastating impacts of Typhoon Yolanda last year and Indian Ocean tsunami in 2005 highlight the critical role of mangrove (and beach) forests in providing buffer zone typhoons, tsunamis and other storm events.

The mixed mangrove-shrimp ponds in Vietnam operated by small farmers have evolved and expanded in area and the government plans to convert all shrimp farms on the southern Ca Mau Peninsula to an integrated landscape of “organic coasts” by 2015. For such initiatives, research on connectivity of juvenile habitats is needed to determine how much pond area can be integrated in mangroves, and in what patterns, without compromising the nursery functions of the latter. For example, conserving an ample seaward mangrove belt of fringing forests gives greater nursery functionality because of the edge effect by which the mangrove-water interface provides access to juvenile shrimp and fish. Developing brackishwater ponds in the landward zone provides a win-win solution of food production from aquaculture compatible with the nursery and coastal services of mangroves.

Mangrove Rehabilitation

The present 1:1 mangrove-pond ratio urgently needs to be increased to the desired 4:1 level by rehabilitating degraded sites, i.e., abandoned ponds and former fringing mangroves, while protecting remaining forests. The Community-based Mangrove Rehabilitation Project of the Zoological Society of London (ZSL-CMRP) ran from 2008 to 2012 with the aim of increasing coastal protection, food resources and livelihood income of coastal communities in Panay and Guimaras by rehabilitating abandoned government-leased fishponds to

mangroves, re-establishing legally mandated coastal greenbelts, and securing tenure on coastal land through Community-based Forest Management Agreements. During the course of the CMRP, close to 100,000 mangroves were planted, with the rehabilitation of 107.8 hectares (56.3 ha ponds and 51.5 ha greenbelt) of mangrove forest underway. More than 4,000 people have been actively engaged in the planting, with many receiving intensive training. These four years have provided many important lessons in mangrove rehabilitation, for both nursery and growout phases, foremost among them the following **20 golden rules** of mangrove rehabilitation:

1. **Assisted regeneration** of mangroves through active planting of seedlings and wildings is required in areas of extensive historic deforestation with highly dependent communities vulnerable to typhoons that have low food security.
2. **Target rehabilitation areas** should be in an intertidal location exposed during neap low tide (instead of spring low tide, the current practice), and reached by seawater during neap high tide. The middle and upper intertidal zones are therefore the most favorable.
3. **Small, backyard nurseries** enable communities to produce sufficient numbers of healthy mangrove seedlings such as *Avicennia marina*, for planting.
4. **Wildings** make an excellent source of plants for rehabilitation, but should be harvested sustainably so as not to affect natural recruitment.
5. **Seafront planting** is more successful using adapted seafront species, particularly *Sonneratia alba*, and by using taller, nursery reared saplings of at least 0.5-1 m height.
6. ***Rhizophora* (bakhaw) propagules** generally do not grow well in seafront zones and therefore cannot be relied upon for mangrove rehabilitation in greenbelts.
7. **Fixed quadrat monitoring** is the simplest, most efficient and robust form of monitoring for large scale rehabilitation initiatives.
8. **Active fishponds** should maintain or achieve a ratio of 4 mangroves: 1 pond area for ecological sustainability.
9. **Abandoned fishponds** more easily revert to mangrove forests than exposed seafronts, but they have more complex tenurial issues.

10. **Protective structures**, including breakwaters and barriers, may be required in highly eroded areas with wave action to protect young mangrove plants.
11. **Fences and signage** can help protect young mangrove plants from boat traffic, fishing and gleaning activities, and domestic and wild animals.
12. **Local government and community support** is required from the outset for successful implementation of community based mangrove rehabilitation projects.
13. **Partnerships** with local government, schools and technical support and specialist groups enhance the scale and scope of mangrove rehabilitation.
14. **Train, mobilize and engage communities** so that they are empowered in mangrove rehabilitation projects.
15. **No pay planting** should be promoted, where communities appreciate and recognize the importance of their mangrove resources to their livelihoods and their contribution of labor is the basis for ownership.
16. **Counterpart funding** should be mobilized from communities and partner organizations, to maximize resources and underpin the collaborative approach to rehabilitation projects.
17. **Tenurial instruments**, such as the CBFMA, can be used to sustain community initiatives in the long term.
18. **Livelihoods** should only be established if they are economically, ecologically and culturally sustainable.
19. **Restoration of protective and productive greenbelts** should be seen a means of securing better livelihoods for coastal communities through increased resilience against natural disasters and higher fisheries productivity.
20. **Mangrove ecoparks** protect mangroves, provide a means of income and pride to local communities and are a powerful educational and awareness raising tool.

CP 25
**Marine biodiversity at the SEAFDEC/AQD aquaculture stations
in Iloilo and Guimaras, Philippines**

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Marine resources and ecosystems must be adequately known to be sustainably used. Such knowledge has been generally taken for granted or overlooked by aquaculture practitioners and even research institutions. Partly as a result of such historical oversight, aquaculture has been accused by some scientists and by media of having caused loss of biodiversity, in many cases even without sufficient documentation, such as before-and-after data. To address such oversight even belatedly, species inventories were recently made in and around the research stations of SEAFDEC/AQD to facilitate subsequent monitoring. AQD's Tigbauan Main Station (TMS, since 1973) faces the deep open waters of the Panay Gulf and Sulu Sea and is flanked by densely populated fishing villages operating near shore fish corrals, gillnets, longlines, and beach seines. In 2013, sampling at the sand-gravel intertidal and monitoring of the catch of the various gears showed at least 550 species in 200 families, including 240 fishes, 230 mollusks, 40 crustaceans, 10 cnidarians, and 10 echinoderms, 15 seaweeds, sea turtles, and sea snakes in the waters off TMS. Any adverse effect of the TMS hatcheries and laboratories is difficult to discern on top of the continuous intense fishing and habitat disturbance. AQD's Igang Marine Station (IMS, since 1980) is in a cove under the rocky cliffs of southern Guimaras, behind several islands facing the Panay Gulf and Sulu Sea. IMS includes 40 ha of seagrass beds and sandflats around five rocky islets and two 6-12 m deep basins where broodstock and grow-out cages are moored. IMS is flanked by many fish corrals operated by fishers who live in villages in nearby coves. Fishers also use gillnets and spears and others glean for mollusks and echinoderms inside IMS. In 2011-2012, some 850 species in 260 families were collected or photographed at IMS, including 95 fishes, 43 crustaceans, 415 mollusks, 50 echinoderms, 97 cnidarians, 53 poriferans, 24 ascidians, and 12 bryozoans, and sea snakes living among 48 seaweeds and 4 seagrasses. Most invertebrates and seaweeds attached to the net cages and

the plastic and bamboo platforms are common in the natural habitats, but some are not. Biodiversity at IMS seems high despite 30 years of operation of the fish cages and the continuous fishing and gleaning by the locals. The cages provide additional attachment surfaces for many species; these 'biofoulants' presumably reduce water flow into the cages but they also remove nutrients and particulate wastes and help maintain good water quality. Nevertheless, siltation is evident under the cliffs inside the cove, and the sandflats may be expanding over the seagrass beds. AQD's 16-ha Dumangas Brackishwater Station (DBS, since 1998) is flanked by freshwater Talaugis River, by hundreds of hectares of mangrove-derived fish ponds, and by Pulao Creek and an extensive mudflat with fringing mangroves at the northern end of Iloilo Strait. In 2009-2010, 18 ponds with water areas from 0.5 to 0.9 ha were sampled during harvest of the experimental crops. At least 102 species of non-crop fishes lived in the DBS ponds, along with 114 mollusks, 44 crustaceans, two echinoderms, two cnidarians, a water snake, and water birds. The snails *Cerithideopsilla* spp., *Cerithiumcoralium*, and *Batillaria* spp. were very abundant in the ponds. Almost all the same species in the ponds, plus many others, were found in the adjoining fringing mangroves (with ~15 species of trees). The ponds serve as proxy for mangrove lagoons that harbor the young of migratory fishes as well as all life stages of resident species. Several non-crop species inside the IMS cages and the DBS ponds are harvested by the workers and contribute to nutrition and income. Aquaculture farms can be managed for high biodiversity to ensure sustainability.

CP 26

Estimation of energy budget of sea cucumber, *Holothuriascabra*, in integrated multi-trophic aquaculture

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In Southeast Asian counties including the Philippines, aquaculture production continues to increase. Environmental deterioration associated with water and sediment eutrophication by aquaculture effluents is getting to be a problem, sometimes resulting in disease outbreaks and fish kills. Integrated multi-trophic aquaculture (IMTA, i.e. polyculture of organisms from different trophic levels) is one of the promising measures for sustainable aquaculture and a source of supplementary income for aquaculturists.

JIRCAS has been conducting research in collaboration with SEAFDEC/AQD to establish IMTA techniques for small-scale fish farmers in the Philippines, with sea cucumber, *Holothuriascabra*, as the key species. In this paper, an estimate of the nutrient budget of *H. scabra* in polyculture with milkfish (*Chanoschanos*) and Elkhorn sea moss (*Kappaphycusalvarezii*) based on a series of experiments, will be described.

Growth model is fundamental in a time-course estimation of the energy budget of an organism. A tank rearing experiment revealed that the Gompertz growth model, often used for bivalves and macroalgae growth, fits the daily growth pattern of *H. scabra* in both body length and weight up to one year of age. Ammonia excretion rate of *H. scabra* was determined as a

function of body length and weight, both being expressed as a power function of body size. Rearing experiments to determine apparent digestibility of different feed ingredients showed that protein digestibility ranged from 34% - 89% in *H. scabra* with animal protein having higher digestibility than plant protein. The nitrogen (N) content of *H. scabra* and milkfish feed was 5.2% and 6.9%, respectively (dry wt/wt).

Based upon results of the experiments and literature information, N budget of *H. scabra* was calculated as a function of age. For instance, N requirement of one-year old *H. scabra* (175 mm, 260 g) is estimated to be 23.1 mg/day (or 334 mg/day milkfish feed) assuming 100% ingestion and 80% digestibility. N excretion of one-year old *H. scabra* is estimated to sustain growth of 46 g *K. alvarezii*.

CP 27
Stock Enhancement? Why Bother

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There are two approaches to resource enhancement of depleted wild fish stocks: through stock enhancement where aquaculture science plays a central role, or through improved management of fish stocks. This paper presents an argument that despite major advances in stock enhancement technologies (tagging, genetic mapping, numerical modeling techniques), major hurdles in policy framework, science and information gaps, risk mitigation protocols and capacity gap remain. These factors are associated with high and recurring cost that requires medium to long-term solutions that ultimately, improving management and governance to recover depleted stocks will still be the best option available.

CP 28

The Battle Against WSSV: Targeting essential genes for RNA interference to revive the ailing shrimp industry

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The irreversible destruction caused by the infection of white spot syndrome virus (WSSV) in numerous shrimp farms around Asia prompted worldwide research efforts on how to avert further damages brought about by this viral pathogen in the shrimp industry. To date, there are no known effective strategies to combat WSSV infection. Functional studies on genes critical for viral infection, are essential in elucidating shrimp-virus interaction. Here, two genes speculated to be crucial in viral infection: VP9, coding for a non-structural protein and contig23 (c23), a DNA fragment found in shrimp, identified to have high homology with WSSVORF-325, were reported.

Utilizing dsRNA-mediated RNA interference, the involvement of VP9 and c23 in the infectivity of WSSV in giant freshwater prawn, *Macrobrachium rosenbergii* was shown. Silencing of VP9 and contig C23 effectively silenced other regions of the WSSV genome. Injection of shrimps with VP9-, C23-, GFP-dsRNA, challenged with WSSV increased survival rate to 80-100% compared to 20% of the PBS group. To evaluate the potency of VP9-dsRNA, shrimp survivors treated with VP9- and GFP-dsRNA, were re-infected using a higher viral concentration, concurrent with the use of new shrimp samples for the PBS group. Significant survival rate of 67% for the VP9-dsRNA treatment compared to 0% for the GFP-dsRNA and PBS was recorded.

Silencing of VP9 and C23 also inhibited other WSSV region and the conferred high survival rate highlights the involvement of both genes in the infectivity of WSSV in shrimp. Moreover, VP9 proved to be effective in combating WSSV infection in at least 3 different shrimp species; *Marsupenaeus japonicus*, *Penaeus monodon* and *Macrobrachium rosenbergii*. Targeting specific genes for RNAi therapeutics might pave the way for the effective management if not eradication of WSSV infection.

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ABSTRACTS OF POSTER PRESENTATIONS

PO 1
**Preliminary Assessment of the Abundance and Fishery of
Snapping Shrimp *Alpheus sp.* in Calape, Bohol, Philippines**

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Snapping shrimp *Alpheus sp.* is abundant in Calape, Bohol, particularly in coastal areas with a wide intertidal zone, mangroves and mud banks. Locally known as “takla”, it is considered as one of the major seafood delicacies in the municipality. An initial assessment of the natural population and fishery of the snapping shrimp was conducted. Using quadrant sampling, mean density was noted at 7 individuals m⁻², body weight ranging from 3.87-12.86 g individual⁻¹ and total length of 4.78-7.44 cm individual⁻¹. The largest individual was identified as male having larger claws, the size being two time larger than that found in females.. Apart from actual field sampling, a total of 80 shrimp gatherers were surveyed to obtain relevant fishery information for the snapping shrimp. The snapping shrimp is sold in the local public market and traded in hotels and seafood restaurants at PhP50.00 bundle⁻¹ (a bundle averaging 20 pieces) and PhP180.00 a kilo. The current average catch per gatherer is at 75 pieces on a daily basis which is relatively lower compared to the average catch in the 1980s and 1990s ranging from 150-300 pieces day⁻¹. Destruction of mangrove swamps due to fishpond conversion, unabated mangrove cutting for commercial firewood production and unrestricted gathering of snapping shrimps were identified as possible causes for the decline. These baseline data are essential for the local government and the community to come up with appropriate protection and conservation measures. An intensive and comprehensive study on the snapping shrimps ecology and biology also need to be conducted to provide basis for sound and holistic management of this valuable resource..

P02
Reproductive Biology of Christian Crabs
(*Charybdis feriatus*, Linnaeus, 1758) in San Miguel Bay

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The reproductive biology of *Charybdis feriatus* was investigated from April 2012 to March 2013 to determine gonad maturity, GSI, fecundity, breeding cycle and size at first maturity. Monthly samples of 30 crabs were randomly collected for determination of gonadosomatic index (GSI), gonad maturity, and fecundity. Gravimetric and volumetric methods were used to estimate fecundity, and GSI was measured as the percentage of gonad weight to total weight. Maturity stages were based on Kumar et.al, (2000) and Islam S. and Kurokura, H. (2012). Results showed that *Charybdis feriatus* is a continuous breeder with a distinct period of peak reproductive activity during the northeast monsoon in January where higher values of GSI, mature, and ovigerous females were observed. Mean GSI of females and males were 7.35 and 6.27%. Ovigerous females were present year round, the highest occurring in December (50%). Fecundity ranged from 1,513,660 to 6,357,133 eggs. The smallest reproductively active female that was found had a carapace width of 8.3cm. Fecundity was highly correlated with size ($r^2=0.92$). Recommended options for prevention of stock depletion include (1) close season, (2) catch regulation, (3) ban on collection of egg-bearing crabs, and (4) stocking of egg-bearing crabs in spawning tanks and release of its larvae in fishing grounds or marine protected areas.

PO 3

Distribution and Abundance of Hard Clam Shells *Meretrix meretrix* along the Coastal Areas of Panguil Bay, Lanao del Norte, Philippines

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Meretrix meretrix is believed to be abundant in Panguil Bay and, in the absence of relevant fishery statistics, it is useful to quantify their biomass with a view to addressing their fishery potential. This study aims to monitor the gonadal period, identify the associated macrofauna and determine the distribution and abundance of hard clam shells *Meretrix meretrix* along the coastline of four municipalities of Lanao del Norte at Panguil Bay. Four sampling sites were selected and established to achieve and relate some generalities using the transect-quadrat method. Clams were counted, measured and identified. Physico-chemical parameters were also noted every sampling. *Meretrix meretrix* was found to be most abundant in Raw-an Pt. Baroy (28-542 pcs./m²) followed by Mayao, Lala (0.3-26 pcs/m²). *M. meretrix* at Aloha Tubod occurred at low densities (0.1-4 pcs/m²). No hard clam shell was found in Taguitic, Kapatagan. Mean length differed significantly at three locations. The coastal area of Mayao, Lala, had the highest diversity ($H' = 4.236737$) in terms of shell species identified and recorded during the twelve months sampling period. Most of the shells dissected were sexually immature with male shellfishes being more predominant than females. Differences in distribution, density and length size of hard clamshells were compared in this study at four locations. Anthropogenic causes e.g. exploitation as well as environmental parameters such as salinity levels and sediment quality are suggested to be the main causes of the variation. These results will be used as baseline information to properly manage hard clam shell resources in Panguil Bay.

PO 4
Resource assessment of sea cucumber in Northern Iloilo, Central Philippines

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A resource assessment of sea cucumber was conducted in six out of eight coastal towns in Northern Iloilo, a fisheries rich area facing the Visayan Sea in the Central Philippines. A yearlong assessment was conducted in 2012. Fishery dependent survey was done with the use of questionnaires translated into the dialect. Six trained enumerators administered the questionnaires to 114 gatherers and 18 local traders. Fishery independent survey involving Belt Transect Method (BTM) for intertidal areas and Timed-Search Method (TSM) for subtidal areas were conducted in 21 Global Positioning System (GPS) -referenced sampling stations. Sample specimens were also collected and prepared for taxonomic identification. External morphology, internal structures (dissected samples) and spicule analysis were used in the identification.

Fishery dependent survey showed that gleaning (40%) is the most dominant extraction method used. Various methods were also employed including the dangerous compressor diving and the destructive *karas*, a method using a rake-like device to scrape the sea bed. In terms of volume, the most heavily exploited sea cucumber belongs to the *Stichopus* groups. The trade of sea cucumber is dominated by island-based traders. Almost half of the traders are women, signifying that trading is a woman's domain as well. Derived monthly income from sea cucumber trade ranges from PhP 2,000 – 3,000 for gatherers and PhP 2,000 – 5,000 for the traders.

Fishery independent survey resulted in the identification of six sea cucumber genera (*Bohadschia*, *Holothuria*, *Paracaudina*, *Pseudocholochirus* and *Stichopus*). Of the 32 species found belonging to the six genera, only 16 were identified up to the species level. Samples of unidentified specimen were sent to the University of the Philippines- Marine Science Institute (UP MSI) laboratory for molecular taxonomic identification. In terms of species

count, the most dominant genera is *Holothuria* with nine identified and seven unidentified species. *H. impatiens* is also the most dominant sea cucumber found in the area. Further, the recorded catch per unit effort (CPUE) for fishery-independent survey is 3 – 4 pcs/diver/hr.

The resource assessment showed that the trade of sea cucumber is dictated by economic value rather than by ecological abundance. While the scale and extent of sea cucumber fishery in northern Iloilo is small-scale and island based, the study highlights the need for trade regulation and stock enhancement of heavily exploited species as extraction affects the ecological distribution of sea cucumber stocks in the area.

PO 5
Larval Rearing of Silver Therapon (*Leiopotherapon plumbeus*)
in Outdoor Tanks

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Silver therapon (*Leiopotherapon plumbeus*, Kner 1864), locally known as *ayungin*, is an important freshwater food fish species found in Laguna de Bay, the largest lake in the Philippines. Its market price is twice that of other most sought after freshwater fishes such as tilapia and milkfish. However, intense fishing pressure on the species has significantly reduced the wild stock in Laguna de Bay. Studies to develop hatchery techniques for this indigenous freshwater fish species are therefore needed to produce seedstock for possible culture and wild stock rehabilitation.

This study highlights the successful larval rearing of silver therapon in outdoor concrete tanks. Larvae reared in outdoor tanks with natural food (grown two weeks prior to start of larval rearing) reached the juvenile stage 40 days after hatching (DAH) suggesting the presence of some suitable live food organisms in pre-conditioned rearing water. However, larval survival rates were low ($11.58 \pm 6.56\%$ at stocking density of $0.9 \text{ larvae l}^{-1}$), which is probably linked to the density of food items, particularly during the onset of exogenous feeding or due to high stocking density of larvae. To improve the availability of natural food for the larvae, fertilization of the rearing water in the outdoor tanks stocked with larvae at two densities (0.4 and $0.6 \text{ larvae l}^{-1}$) was performed. Larval growth and survival were improved at stocking density of $0.4 \text{ larvae l}^{-1}$ than at $0.6 \text{ larvae l}^{-1}$. Diet composition of first-feeding silver therapon larvae in outdoor tanks inoculated with cultured microalgae

(*Chorella sorokiniana*) and zooplankton was also determined. Larvae were able to consume rotifers and some phytoplankton beginning at 2 DAH and larger preys such as cladocerans and insect larvae starting at 12 DAH.

The efficacy of raising silver therapon larvae in outdoor tanks using ambient lake water was also evaluated. Larvae reared in ambient lake water grew well but survival ($48.44 \pm 7.85\%$) was significantly improved in treatments where tropical almond or talisay *Terminalia catappa* leaves were added during the first two weeks of larval rearing.

P06

Preliminary Trials on the Effects of Weaning and Larval Diets on Survival and Growth of Silver Therapon (*Leiopotherapon plumbeus*) larvae

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Success in larval rearing of silver therapon can be achieved through early weaning of fish larvae from live food to artificial diet. Two experiments were carried out to investigate the effects of (a) weaning age (abrupt and gradual) and (b) larval diets (artificial and live foods) on survival and growth of silver therapon (*Leiopotherapon plumbeus*). In the first experiment, larvae were randomly stocked in round 4-l plastic basins at 15 larvae per basin to provide triplicates of four weaning age treatments (8, 14, 20 and 26 days after hatching or DAH, respectively). Larvae were fed thrice daily for 21 days with commercial feed (CF) and with copepods (COP) which served as the control. Larvae weaned at 26 DAH had the highest survival, body weight and total length among the treatment groups, which were comparable with that of the control. In the co-feeding protocol, larvae were fed *Artemia* nauplii (ART) as the control group and co-fed with either zooplankton i.e. 50% COP + 50% CF or 50% ART + 50% CF for 8 (8-15 DAH), 6 (14-19 DAH) and 4 (20-23 DAH) days, and suddenly weaned to FM until 21 days. Survival ranged from 22.2 ± 16.8 to $40.0 \pm 24.0\%$ between treatments, but was still lower than the control ($88.9 \pm 3.8\%$). Body weight and total length were significantly higher in larvae with co-feeding for 4 days (70.1 ± 2.8 mg; 18.1 ± 0.8 mm), but were still lower than that of the control (142.8 ± 7.6 mg; 22.3 ± 0.3 mm).

In the second experiment, 26-day old larvae were stocked in 20-l glass aquaria at 4 larvae l⁻¹. Larval diets (I) commercial prawn feed (38% crude protein); (II) *Artemia* nauplii; (III) copepods; and (IV) free-living nematode *Panagrellus redivivus* were given twice daily for 28 days. Survival was highest in larvae fed *Artemia* nauplii and lowest in copepod-fed larvae. Final total length (TL) of larvae fed prawn diet was higher than those fed copepod or nematodes. However, best growth was noted in larvae fed *Artemia* nauplii (TL= 24.30 ± 0.81 mm; BW = 156 ± 8 mg; specific growth rate or SGR = 5.33 ± 0.19%/d).

P07

Optimization of Feeding and Growth Conditions for Hatchery-bred Larvae of Indigenous Philippine Silver Perch, *Leiopotherapon plumbeus* (Perciformes: Terapontidae)

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The Philippine silver perch, locally known as *ayungin*, is an endemic fish species and is considered as a potential candidate for aquaculture and for stock enhancement. However, high mortality associated with early larval stages presents a significant bottleneck to its latent commercialization. Culture experiments considered interactions among prey proportions, growth conditions and their consequences on fish growth performance and survival. Two phases of the experiment were conducted: (1) a short duration feeding trial utilizing different prey proportions of *Brachionus calyciflorus* and *Moinamacrocopa* and (2) an indoor larval rearing technique that ensured optimum growth and survival of juveniles. Findings of this research will be used to propose an efficient rearing strategy addressing the aquaculture of this indigenous species.

PO 8
**Preliminary Trials on the Optimization of Hormone Dosages
for Induced Breeding of Philippine silver
perch, *Leiopotherapon plumbeus***

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The silver perch *Leiopotherapon plumbeus*, locally known as ayungin, is an endemic freshwater fish that is commercially valuable as it commands a high price in the local market. Due to excessive fishing and other potential causes such as predation by invasive alien species, the local *L. plumbeus* stocks are observed to be depleting hence there is a need for an induced breeding protocol to propagate silver perch and conserve what remains of the resource. Various dosages of human chorionic gonadotropin (HCG), leutenizing hormone releasing hormone (LHRH) and salmon gonadotropin releasing hormone (sGNRH) were evaluated to identify the most effective dosage and hormone that resulted to high ovulation, fertilization and hatching rate. For the hormone sGNRH, 20, 30 and 40 µg/kg body weight and 1, 2 and 3 µg/kg body weight for LHRH were the dosages used in the experiment. The dosage used for HCG was 5000 IU and served as the control. The findings of the experiment determined that the use of 20 µg/kg body weight of sGNRH resulted to high ovulation, fertilization and hatching rates. The result of the experiment would provide an efficient protocol for the local fishermen so they can produce, on demand, a large supply of this high quality fish species.

Growth and Survival of Nile Tilapia (*Oreochromis niloticus*) Juveniles Fed Diets with Varying Levels of Irradiated Chitosan

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Chitin is a natural biopolymer and the second most abundant after cellulose. Chitosan, a derivative of chitin which is soluble in acidic aqueous media, is used in many applications like food, cosmetics, biomedical and pharmaceutical products. It is used in agriculture for enhancing growth in crops while in aquaculture, chitosan is believed to improve the immune response of fish to stress-inducing agents, thus enhancing survival and possibly growth. This preliminary study was conducted to investigate the effects of various concentrations of irradiated chitosan on the growth performance of Nile tilapia, *Oreochromis niloticus*. Fish was fed with a control diet and three formulated diets containing increasing levels of irradiated chitosan (10g, 20g and 50g Kg⁻¹). Juvenile *O. niloticus* was fed once daily for 21 days. The ration was based on 5% of the fish biomass. Tilapia fingerlings (n=30 per tank) of uniform size were randomly distributed in four experimental groups each with three replicates following a completely randomized design. Growth and food utilization parameters were measured. Specific Growth Rate (SGR), Mean Weight Gain (MWG), Mean Length Increment (MLI) and Feed Conversion Ratio (FCR) were computed and analyzed using ANCOVA. Results from the feeding trials showed no significant difference (P>0.05) in the different performance parameters under the different fish feed treatments. MWG, MLG, SGR and FCR varied in the stocks fed different fish feed treatments but with no significant differences. The results also showed 45-62% survival rate. These suggest that although there is no significant difference between treatments and control, irradiated chitosan-supplemented diets do not retard the growth of *O. niloticus*. Chitosan should be studied further to determine how it can improve the growth performance, feed utilization and immune response of Nile tilapia.

PO10
**Growth Performance of Brackishwater-Enhanced Selected
Tilapia (BEST) reared in Brackishwater Ponds**

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Tilapia culture contributes greatly to world aquaculture production. Several tilapia strains have been developed locally and one of these have been developed for brackishwater aquaculture. BEST or the Brackishwater Enhanced Selected Tilapia has been developed by the Bureau of Fisheries and Aquatic Resources with the aim of promoting brackishwater culture of this commodity to further improve tilapia production in the Philippines. This study will determine the growth performance of BEST reared in organically fertilized brackishwater ponds at three different stocking densities.

The study was conducted in nine (9) units of 200m² ponds. Pond preparation was done following standard procedures which include drying, liming, teaseed application and fertilization. Stocking was done after twenty days when primary productivity in the ponds was noted. Three culture systems were used, namely: extensive (T1), semi-intensive (T2) and intensive (T3) systems. The study was conducted for 120 days. Results showed that fish in extensive ponds T1 had an average body weight (ABW) of 52.1g, T2 stocks with ABW of 223.1 g and T3 stocks with an ABW of 214.5g. Meanwhile, T1 stocks had a survival rate of 91.9% while stocks under T2 and T3 had survival rates of 80 % and 84% respectively. It was also noted that T1 gave a total revenue of P 958 with a total cost of P 1,340 giving a net return of P 382. T2 harvest on the other hand registered a total revenue of P 10,368 and total cost of P 4,374.85 and net return of P 5,633.75. T3 also had total revenue of P 21,419.20 with a total cost of over P 8,498.1 giving a net return of P12, 471.1. Return of investment (ROI) for T1 was at -

0.28, while T2 had a ROI of 1.28 and a payback period of 0.77. T3 had a ROI of 1.39 and payback period of 0.71. Average feed conversion ratio (FCR) in two runs was the same for two treatments at 1.1. Water parameters like DO, salinity, temperature; water level and pH were also monitored. Water level in the ponds ranged from 70 to 74 cm, salinity at 6.3-6.9 ppt, DO at 1.5-1.7ppm, temperature at a constant 29°C, monthly pH range of 7.1-8.0 and transparency of 34-47 cm.

P011
**A Preliminary Study on the Diagnosis of Coral Reef
Healthiness and Establishment of Coral Replenishment
Technology**

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Coral reef areas hold extraordinary biodiversity and play important roles, such as nursery, grow-out, and spawning grounds, *etc.* for a huge number of marine aquatic organisms which include very important species for fisheries in tropical areas. Under recently changing environments, however, coral reefs are gradually deteriorating worldwide due not only to climate change, but also to rampant overfishing and illegal fishing. In the Philippines, which is the third largest reef nation and one of the most diverse region of the world for coral reefs, only 4 % of the 26,000 sq. km total coral reef areas is in excellent condition. Since sustainable utilization of aquatic resources cannot be realized without healthy aquatic ecosystems, the rehabilitation of coral reef areas and/or maintenance of coral healthiness are pressing issues in our region. The present study aims to offer baseline information that can contribute to efforts in coral restoration. Field surveys for coral reef, through line-intercept-transect and temperature profiling using data-loggers done at three layers of 5, 10, and 15 m depths in coral reef areas, Nogas Island, Anini-y, Antique, Philippines showed that both coverages of substrates by any type of organism and by Scleractinia decreased in the deeper layers. For Scleractinia, *Porites* sp. occurred predominantly in all the depth layers with the occurrence decreasing with depth. Temperature fluctuation was largest in the 5 m depth layer, where effects of tidal level were also confirmed. While the average temperature decreased with depth, this did not differ beyond 1°C between 5 and 15 m layers during November 2012 to March 2013. Among fragments of *Acropora* sp. sampled and transferred to aquaria at the Tigbauan Main Station of SEAFDEC/AQD, those

sampled from the deepest layer alone showed bleaching and thereafter a part of the fragments regained the color. Experimental trials to clarify the effects of ocean acidification and warming on the healthiness of the coral using the live fragments of *Porites* sp. showed decreasing trends in both photosynthetic rates and daily growth rates in acidic condition (pH 7.6), while decrease of zooxanthellae density was observed under warmer conditions (31°C) for one month. A new methodology was established for the determination of density of zooxanthellae. In this study, the need for studies on several coral communities as well as further basic research on coral biology, particularly, responses to the changing environments, are discussed for diagnosis of coral reef healthiness and establishment of effective coral replenishment technology.

PO 12

Seafarers' Perception on the Effects of Maritime Activities on the Philippine Aquatic Ecosystem

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Throughout history, humans create an impact on marine ecosystems. May it be positive or negative, such impact is long-term and shapes the overall image of the system. And as humanity increases its number, so does the impact it creates. Humanity has relied on the oceans for food, recreation and for various economic opportunities. Overfishing and pollution affects the life in the seas. Advancements in fishing technology, such as tracking technologies and better transportation have reduced fish stocks significantly when matched with non-sustainable practices, such as dredging and trawling. Intentional dumping from sewages, industrial run-off and chemicals have caused pollution to the seas. Though some pollution may be accidental, like oil spills, it still causes adverse effects to the sea. Excess nutrients coming from fertilizers and intensive farming practices have resulted to what is known as eutrophication. Lastly, changes in the marine environment have led to the introduction of invasive alien species and marine organisms, which are oftentimes difficult to eradicate. Such effects have made researchers rethink of various ways to maintain marine activities while sustaining its ecosystem.

Through this study, the researchers determined the effects of maritime activities on the population of aquatic creatures directly from the seafarers, and found out their perspectives on how to remedy such effects and sustain the marine ecosystem.

This research is descriptive in nature, conducted with 100 purposively selected seafarers from Manila. The participants were given a questionnaire that asked for demographics and their perceptions on the effects of maritime activities on the marine ecosystem and ways to provide solutions to minimize or avoid its negative impacts.

Findings show equal distribution on gender, with majority at the low socioeconomic level (47%) and are Tagalog in ethnicity (56%). The seafarers believe that the maritime activities cause harm on aquatic creatures (43%), limits propagation of aquatic species (36%), makes them prone to mortality (11%) and cause pollution to the atmosphere (10%). Likewise, their perception of minimizing the consequences lies within the proper conditioning of ships and running them in good condition (57%), maintaining a clean place for the marine inhabitants (28%) and creating a good waste-renewal system (15%). The results of the paper is directed towards proper handling and maintenance of the shipping industry and strict supervision of waste management

PO 13
**Modelling the impact of Different Stress Agents on Holothurian
Immunity**

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Due to dietetic and pharmacological values of many species of sea cucumbers (Holothuroidea, Echinodermata), and depletion of their natural resources, the species of little or no commercial value attract attention as new raw material resource, and methods of their aquaculture are developed. Both monitoring and supporting the health of animals in natural and artificial conditions demand the approaches providing reliable markers. This study compared the influence of two stress agents, namely lead and bacterial toxin *Yersinia pseudotuberculosis* (TcTYp), on some of the markers of immune response of the Far Eastern holothurian *Eupentacta fraudatrix*. Phagocytes (P2 type) were isolated after 48 h treatment of holothurians *E. fraudatrix* with $Pb(NO_3)_2$ (2 and 4 mg/L). In another experiment, coelomocyte were incubated with TcTYp (0.2 and 0.5 $\mu\text{g/g}$) for 18 h. Apoptosis level and FITC-conjugated concanavalin A (con A) and binding of lectins from *Glycin Max* and *Dolichos biflorus* to P2 surface receptors, and activity of antioxidant enzymes were measured.

Lead induced an increase in catalase and decreases in superoxide dismutase and glutathione-S-transferase and glutathione reductase activities at a dose of 2mg/L but not 4 mg/L. A dose of 2 mg/L lead also increased apoptosis level. Noteworthy, receptors to lectins from *G. Max* and *D. biflorus* were poorly expressed in the control, and significantly expressed under lead treatment at a dose of 2 but not 4 mg/L (*D. biflorus*) or decreased at a dose of 2 but not 4 mg/L (*G. Max*). Binding con A was significant in the control and additionally increased under treatment with 2, but not 4 mg/L. Meanwhile, TcTYp also

induced reversed concentration-dependent effect on apoptosis: 48 h incubation with 0.5 $\mu\text{g/g}$ decreased apoptosis, and 0.2 $\mu\text{g/g}$ -increased it. Additionally, 0.2 $\mu\text{g/g}$ TcTYp decreased binding con A and *D. biflorus* lectin. Commercially available catalase restored % lectin binding to the control level.

Data obtained indicate that lead and TcTYp differently influenced phagocyte activity, and complex definition of apoptosis level and activity of antioxidant enzymes. Finally, variations in expression of cell surface receptors may be useful for estimation of the level of stress damage to holothurians.

**First Record of Laem-Singh Virus in Black Tiger Shrimp
Penaeus monodon in the Philippines**

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Laem-Singh Virus (LSNV) is a single-stranded RNA virus that causes growth retardation, also known as Monodon Slow Growth Syndrome (MSGs) in *Penaeus monodon*. Black Tiger shrimps afflicted with this virus exhibit unusual dark color, a weight gain of less than 0.1 g in 1 to 2 weeks, unusual yellow markings, “bamboo-shaped” abdominal markings and brittle antennae. It was first detected in Thailand and the virus quickly spread to neighboring Asian countries such as Malaysia and Singapore. The shrimp economy of infected countries experienced losses in the export of live shrimps and broodstock. An earlier study in 2009 reported that LSNV was not present in the Philippines. However, since no follow-up researches were done in the succeeding years, this study was conducted to detect the presence of virus in selected sites of Luzon. Results based on biased sampling method and RT-PCR data indicated that LSNV is indeed present in the country. This is further supported by DNA sequence data showing 100% identity with LSNV India isolate. Phylogenetic analysis showed that the Philippine isolate clustered closely with other LSNV isolates. The outcome of this study might have implications in the current practices in the Philippine shrimp aquaculture industry

PO 15
Development of a Simple, Rapid, Cost-effective Diagnostic Kit for WSSV

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Shrimp aquaculture is one of the most important sources of income and livelihood in the Philippines. For the past two decades, the white spot syndrome virus (WSSV) has adversely affected the production of the Philippine shrimp industry, resulting to revenue losses. Shrimps infected by the virus experience up to 100% mortality, 3 to 10 days post-infection. One way of controlling the disease is early detection, which remains to be too complicated and inaccessible to shrimp farmers. Being a DNA virus, the first step to WSSV diagnosis is the isolation of high-quality DNA suitable for polymerase chain reaction (PCR) or loop-mediated isothermal amplification (LAMP). Using readily available and affordable reagents, a DNA extraction protocol has been especially developed for rapid WSSV-detection; DNA has been successfully extracted from the pleopods of shrimps and the results were comparable with that of commercially available kits from Promega and Zymoresearch. LAMP has been optimized for WSSV detection in the temperature range of 55°C to 68°C and was shown to be faster and ten times more sensitive than conventional PCR. This study together with a locally fabricated machine, offers a more convenient, practical and efficient way of detecting WSSV, with the advantage of using non-invasive means of obtaining shrimp tissue therefore not losing any shrimp meat in the process.

PO 16
Shrimp Metabolism: The roles of lactate dehydrogenase (c31), glycogen phosphorylase (c34) and protein kinase (PK) as revealed by RNA interference

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Energy metabolism is well-studied in vertebrate systems, providing insights on the genes and mechanisms involved in different pathways necessary for the survival of an organism. Yet, such studies are still lacking in invertebrate systems, much more in shrimps. An earlier study has showed several contigs from the black tiger shrimp to be homologous to White spot syndrome virus (WSSV), a devastating pathogen in shrimp, including contig 31-WSSVORF82 (c31) and contig 34-WSSVORF21 (c34). This study aims to unveil the roles of three genes: c31, c34 and protein kinase (PK) in the shrimp system and its possible role in WSSV-infection. Rapid amplification of cDNA ends-polymerase chain reaction or RACE-PCR was used to obtain the full-length sequence of c31 and c34, followed by *in vivo* gene silencing using RNAi technology, intramuscularly injecting dsRNA to WSSV-challenged *Macrobrachium rosenbergii* and *Marsupenaeus japonicus*. Gene expression followed for healthy shrimps and dsRNA-treated shrimps.

Mrc31 was revealed to be the enzyme lactate dehydrogenase (LDH), commonly released during tissue damage and is a marker for disease. The most parsimonious tree pictured *Mrc31* to be sister clades to LDH of other shrimp species, *Penaeus monodon* and *Litopenaeus vannamei*, supported with 100% and 72% bootstrap values, respectively. *Mrc34* was highly

homologous to the glycogen phosphorylase (GP) enzymes of other organisms including that of another shrimp, *M. japonicus*, bearing a bootstrap value of 99%. For PK, phylogenetic analysis revealed that the three open reading frames (ORFs) from *P. monodon*, *M. rosenbergii* and *M. japonicus* have 30% homology to WSSV-PK supported by a 98% bootstrap value. Mortality data from dsRNA-treated and WSSV-infected shrimps showed that treatment with dsRNA-LDH, GP and PK had significantly higher survival rates compared to that of the controls, PBS and GFP. Silencing the three genes in the shrimp has rendered some protective effect against the virus. Gene expression showed that all three genes are present in immune-related organs such as the gills, hepatopancreas and hemocyte. This study is the first to report on the possible identities and functions of contigs 31, 34 and PK providing valuable data in the shrimp's genome.

P017

Modulation of Innate Immune Response of WSSV - infected *Macrobrachium rosenbergii* Administered with *Gracilaria edulis* Extracts

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White spot syndrome virus (WSSV) is the most devastating pathogen in decapod crustaceans causing up to 100% mortality in shrimp cultures within 3 to 10 days from the onset of the disease. In this study, the immunomodulatory potential of *Gracilaria edulis* extracts was reported in *Macrobrachium rosenbergii* challenged with WSSV via immersion and feeding.

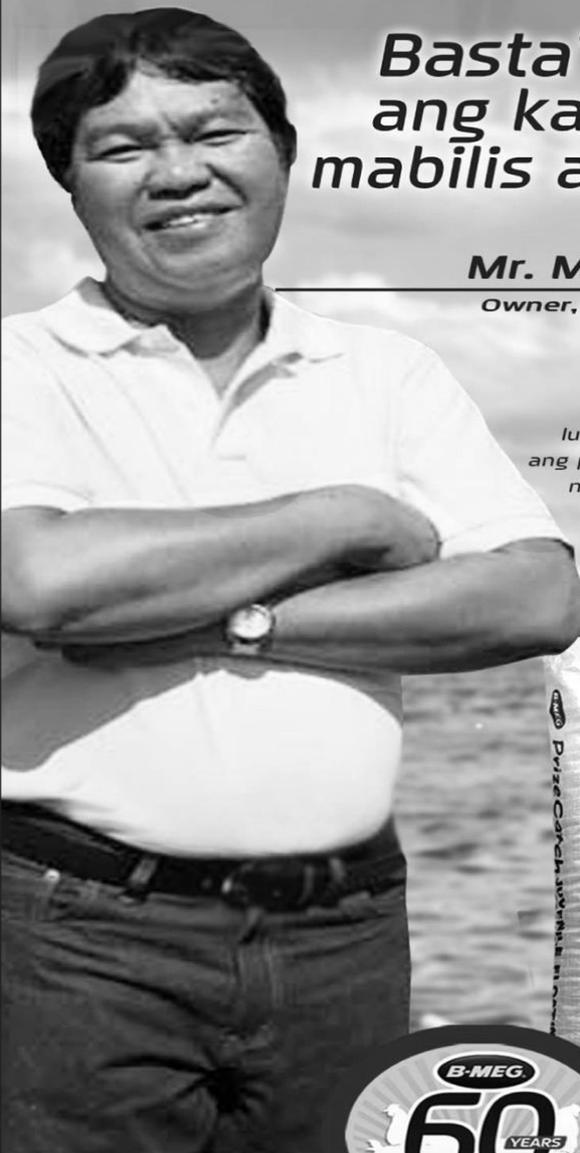
This study involved the administration of 0.10% methanolic extracts incorporated in shrimp feeds and 1% aqueous extracts used via immersion test. Shrimps received the extracts before and after viral infection for 56 days for the prophylactic set-up. This set-up was designed to determine the immune response of uninfected shrimps immersed in extracts for 28 days and to test the consistent immunostimulatory effect of *G. edulis* extracts until the 56th day after infection. Another group of shrimps received the extracts for 28 days after infection for the therapeutic set-up designed to determine the immune response of WSSV- infected shrimps immersed in extracts for 28 days and to prove the efficacy of extracts as treatment for infected shrimps.

The immune responses were evaluated by analysis of total haemocyte count and prophenoloxidase activity. These parameters were increased significantly when WSSV-infected shrimps immersed in water containing 1% aqueous extracts and in shrimps treated with 0.10% methanolic

extracts. The results were strongly supported by the significant increase in survival rate of shrimps treated with the *Gracilaria* extracts via immersion and feeding than that of the control groups when subjected to one-way ANOVA statistical analysis.

In summary, immersion in 1% aqueous extracts and incorporating 0.10% methanolic extracts in feeds of infected *M. rosenbergii* showed increased immune ability as well as resistance to white spot syndrome virus. These results will provide a means of producing eco-friendly formulations, cost-effective approach and more efficient strategies against shrimp viral diseases, as well as improving growth and production.

EXHIBITOR

A black and white photograph of Mr. Minong Tenorio, a middle-aged man with dark hair, wearing a white polo shirt and dark trousers. He has his arms crossed and is smiling slightly. He is standing in front of a large bag of B-MEG Prize Catch fish feed. The background is a bright, slightly hazy outdoor setting, possibly a farm or a body of water.

**Basta't B-MEG
ang kanegosyo,
mabilis ang asenso.**

Mr. Minong Tenorio

Owner, King Benjie Fish Farm

*"Magmula nang B-MEG
Prize Catch Fish Feeds
ang ginamit ko, mas mabilis
lumaki ang mga isda, mas sulit
ang pakain. Kapansin-pansin din
nasiksikang laman. Dahil dito,
mas maganda ang kita ko!"*





FEEDING GUIDE

TILAPIA

	FINGERLING Pellet 25 kg	JUVENILE Pellet 25 kg	ADULT Pellet 25 kg
WEIGHT RANGE	20 - 100 g	100 - 300 g	300 - 500 g up
DAYS OF FEEDING	45	50	45
FEEDING RATE/ABW	5 - 4%	4 - 3.5%	3.5 - 2%

BANGUS

	FINGERLING Pellet 25 kg	JUVENILE Pellet 25 kg	ADULT Pellet 25 kg
WEIGHT RANGE	10 - 100 g	100 - 300 g	300 - 500 g up
DAYS OF FEEDING	55	60	50
FEEDING RATE/ABW	5 - 4%	4 - 3.5%	3.5 - 2%

GUARANTEED ANALYSIS

	FINGERLING Crumble 20 kg	JUVENILE Pellet 25 kg	ADULT Pellet 25 kg
Crude Protein	31	30	28
Crude Fiber	6	7	7
Crude Fat	4	6	4
Ash	15	16	13
Moisture	12	12	12

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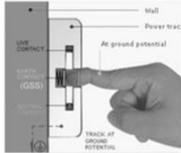
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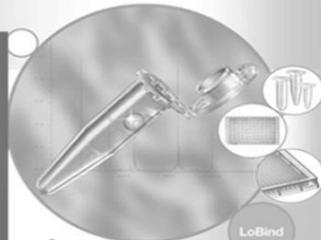
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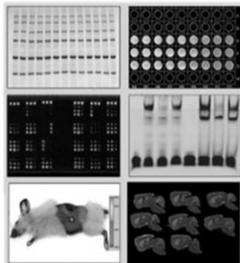
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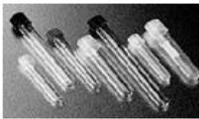


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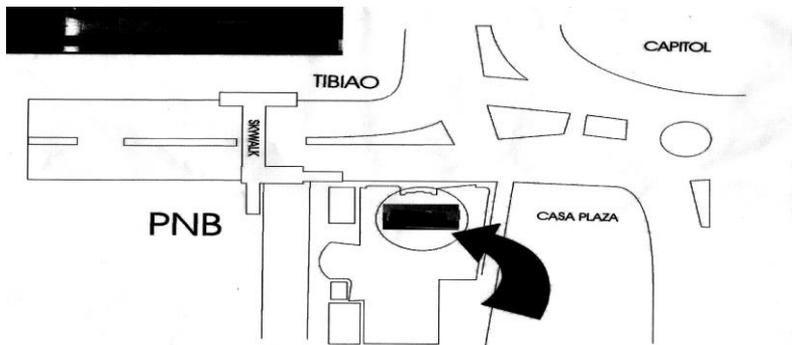
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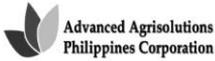
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ABOUT SEAFDEC

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in December 1967 to promote fisheries development in the region. The member countries are Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.



The policy-making body of SEAFDEC is the Council of Directors, made up of representatives of the member countries.

SEAFDEC has four departments that focus on different aspects of fisheries development:

- The Training Department (TD) in Samut Prakan, Thailand (1967) for training in marine capture fisheries
- The Marine Fisheries Research Department (MFRD) in Singapore (1967) for post-harvest technologies
- The Aquaculture Department (AQD) in Tigbauan, Iloilo, Philippines (1973) for aquaculture research and development, and
- The Marine Fishery Resources Development and Management Department (MFRDMD) in Kuala Terengganu, Malaysia (1992) for the development and management of fishery resources in the exclusive economic zones of SEAFDEC member countries.

AQD is mandated to:

- Conduct scientific research to generate aquaculture technologies appropriate for Southeast Asia
- Develop managerial, technical and skilled manpower for the aquaculture sector
- Produce, disseminate and exchange aquaculture information

AQD maintains four stations: the Tigbauan Main Station and Dumangas Brackishwater Station in Iloilo province; the Igang Marine Station in Guimaras province; and the Binangonan Freshwater Station in Rizal province. AQD also has an office in Quezon City.

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