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SEAFDEC/AQD Highlights 2006



AQUACULTURE DEPARTMENT
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines

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The SEAFDEC/AQD chief reports

SEAFDEC/AQD spent its 33rd year of aquaculture research and development with significant strides in generating science-based technologies for breeding and farming of commercially important aquaculture commodities.

Our present programs are classified into two: departmental programs and those programs of the SEAFDEC Special 5-year Program on Sustainable Fisheries for Food Security in the ASEAN Region that are implemented through the ASEAN-SEAFDEC Fisheries Consultative Group (FCG) mechanism.

We have six departmental programs: 1) integrated mollusk program, 2) mud crab program, 3) shrimp domestication program, 4) marine fish program, 5) smallholder freshwater aquaculture program, and 6) seaweed strain improvement program.

Under the ASEAN FCG is the aquaculture component on technology development and human capacity building; the other component programs are the responsibility of other SEAFDEC departments. Also under the ASEAN FCG are two more programs: development of a fish disease surveillance system and stock enhancement for species of international concern like giant clam and abalone. Both are funded by the Government of Japan Trust Fund.

The framework of our research and development activities revolves around our primary stakeholder – the aquaculture industry. By industry, we mean both big-time private sector and small-scale people's cooperatives. Hence, all research efforts will extend to technology verification and technology commercialization in a continuous process.

On 27 June 2006, we convened an in-house workshop. We reviewed the technologies developed by our Research Division, identified gaps for further research and verification and made plans for dissemination of our research findings. Our scientists also identified our technologies for verification. Following this workshop,

we went full swing in undertaking research and verification studies aimed at addressing the gaps and also in fine tuning the technologies on seed production to grow-out culture systems for various commodities.

For hatcheries, we shall test and verify the following technologies:

- SEAFDEC/AQD-developed diets for milkfish, rabbitfish, grouper, sea bass and snapper
- Refined hatchery protocol up to nursery phase for mud crab
- Refined hatchery and nursery protocol in tanks and cages for abalone
- Up-scaling of *Kappaphycus* plants and regenerants from tissue culture

For grow-out culture, these technologies will be verified:

- Green water culture system
- Indigenous probiotics in tiger shrimp ponds
- Integrated shrimp-oyster-tilapia-seaweed culture
- Fry to fingerling production of milkfish, bighead carp, and native catfish
- Use of SEAFDEC/AQD-developed diets for mud crab, grouper, sea bass, snapper, milkfish, *P. indicus*
- Use of metaldehyde in management of pond snails in milkfish farms
- Grow-out in lake-based cages for catfish and *Macrobrachium*
- Pond culture of *Gracilaria*
- Use of seaweeds as biofilter in fish cages and recirculating systems.

Our scientists and their support staff have embarked on facilitating the dissemination and commercialization of viable technologies to farmers, both locally and internationally. At the village level, we are helping enhance the capacity of our local communities through participatory and interdisciplinary approach in the transfer and adoption of SEAFDEC/AQD-developed technologies on aquaculture and resource management.



Dr. Joebert D. Toledo
Chief, SEAFDEC/AQD

Backed by our successful experience in our project on coastal resources management in Malalison Island in Panay, Philippines a few years back, we started last year what we call our “dream project on aquaculture.”

Our three main divisions – research, training and information, and technology verification and commercialization, with the full support of the administration and finance division – were in the forefront of this 2006 major activity. We are trying out a holistic concept of technology transfer in two provinces in the Philippines: Antique and Capiz in Panay Island. This project is officially titled “Institutional capacity development for sustainable aquaculture.”

We also continued the conduct of our regular and special training programs, especially for the Region and the Philippines’ aquaculture research and development workers, fish farmers, academicians, and other private individuals. Notable among these were our collaborative training program with the ASEAN Human Resources Development project on sustainable fisheries in the Brunei Darussalam-Indonesia-Malaysia-Philippines East Asia Growth Area (BIMP-EAGA), an international training course on marine fish hatchery, abalone hatchery, seed production and culture, and several sessions on freshwater aquaculture training for fish farmers.

Most of our activities in 2006 will be continued in the coming year. Programs will still be commodity-based and will continue to address the technology needs of the Philippines and other Southeast Asian countries. Research will be focused on harnessing biotechnology to improve production efficiency, particularly in the areas of broodstock development, seed production, and grow-out culture systems.

We will continue to generate science-based information, publish these in peer-reviewed journals and at the same time put emphasis on verifying and packaging viable technologies for transfer to farmers.

We will also exert complementary efforts in fund sourcing to improve our overall financial standing, in seeking more collaboration with important research partners and stakeholder groups, and in improving SEAFDEC/AQD’s visibility in the local and international scene.

Organization of regular training courses in the areas of our specialization and updating of information materials, especially manuals, and our website will also form an integral part of our activities next year.

Finally, we shall always ensure that all of our activities are geared towards generation of jobs and food security in the region.



SEAFDEC/AQD's research and development programs

The current research and development (R&D) programs of SEAFDEC/AQD follow a continuous cycle. Research issues are identified according to problem urgency, seriousness and scope as they affect the players in the aquaculture industry.

In the previous year, the R&D programs focused on current issues and problems affecting major fish species. The aquaculture commodities have been previously identified as priorities for research work not only in the host country, the Philippines but also in Southeast Asia.

Starting from the needed basic research on important fishery commodities, SEAFDEC/AQD has constantly fine-tuned its activities to cater to the needs of its stakeholders in the aquaculture industry. These stakeholders are fishfarmers, government extension officers, staff of academic and research institutions, donors and policy makers.

Technologies generated from its research activities are then tested and piloted in technology verification trials in selected fish farms and cooperators. The research and technology verification information are also communicated and transferred to the industry stakeholders through the SEAFDEC/AQD's training and information dissemination programs.

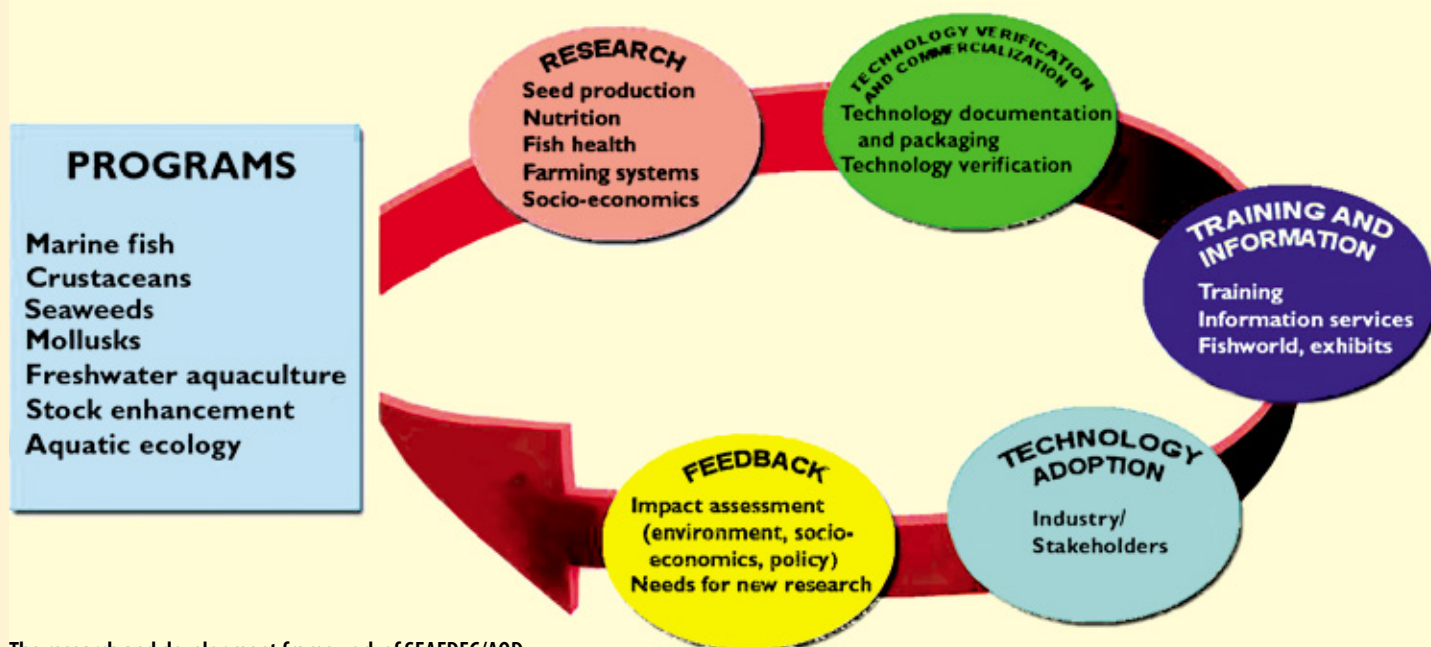
SEAFDEC/AQD also keeps tab on the adoption of its technologies by conducting impact assessment studies. Results of these studies serve as a guide for researchers in attuning their research and development programs to immediate needs and concerns.

Two Major Programs

SEAFDEC/AQD's programs are classified into two: departmental and regional.

The departmental activities are those conducted by the respective SEAFDEC departments. Regional activities are those conducted by each SEAFDEC department under the SEAFDEC Special 5-year Program on Sustainable Fisheries for Food Security in the ASEAN Region (2006-2010). These activities are being implemented under the ASEAN-SEAFDEC Fisheries Consultative Group (FCG) mechanism.

In June 2006, SEAFDEC/AQD convened an in-house workshop that identified technical gaps for further research and verification. This workshop also formulated plans for information dissemination and transfer to farmers.



The research and development framework of SEAFDEC/AQD.

Based on these outcomes, departmental programs have embarked on new activities that are in line with re-defined thrusts. These programs have a five-year duration from 2006-2010.

The activities under these programs focus on research and verification of aquaculture technologies in support of the intensified FCG Programs in the ASEAN region. These activities are in line with the areas of importance and priority needs of the region, i.e. broodstock development, genetic improvement, seed production, and grow-out culture.

These programs are funded by the host government, the Philippines. Research is normally conducted solely by SEAFDEC/AQD's own scientists or in collaboration with private and public institutions. The departmental programs are the following:

- 1) Integrated Mollusk Program
- 2) Mud Crab Program
- 3) Shrimp Domestication Program
- 4) Marine Fish Program
- 5) Smallholder Freshwater Aquaculture Program
- 6) Seaweed Strain Improvement Program

SEAFDEC/AQD implements three programs under the ASEAN FCG mechanism:

- 1) Special 5-year Program on Sustainable Fisheries for Food Security in the ASEAN Region, Component II-Aquaculture
- 2) Development of a fish disease surveillance system, five years (2004-2008)
- 3) Stock enhancement for species of international concern, five years (2005-2009)

The first program is funded by the Government of Japan through the ASEAN Foundation. There are two five-year projects (2006-2010) under this program: 1) Development of technologies for sustainable aquaculture and 2) Human capacity building for sustainable aquaculture.

The last two programs are financed by the Government of Japan Trust Fund.

Under these programs, SEAFDEC/AQD researchers carry the lead responsibility and work in close collaboration with scientists of the SEAFDEC and ASEAN member countries.



SEAFDEC/AQD R&D Projects, 2006

STUDY TITLE	STUDY LEADER	PERCENT COMPLETION	B U D G E T		COLLABORATING UNIT
			SEAFDEC	EXTERNAL	
DEPARTMENTAL PROGRAMS					
Integrated Mollusk Program					
1	Pilot-testing on the propagation and use of diatoms (<i>Amphora</i> and <i>Navicula</i> sp) for larval settlement of the donkey's ear abalone <i>Haliotis asinina</i> (Linne)	MR de la Peña	80%	129,800	
2	Nursery rearing of abalone (<i>Haliotis asinina</i>) in land-based flow-through tanks and in floating sea cages	AC Fermin	90%	215,000	
3	Refinement of seed production techniques for abalone <i>Haliotis asinina</i>	SM Buen-Ursua	75%	1,435,517	
4	Grow-out culture of abalone (<i>Haliotis asinina</i>) in floating sea cages	AC Fermin	10%	347,500	Rotary Club of Iloilo
Mud Crab Program					
5	Refinement of broodstock management and seed production techniques (mud crab)	ET Quinitio	70%	904,150	
6	("Refinement of hatchery and nursery of mud crab") Cost-effective culture, harvesting and preservation techniques of green microalgae for crab and fish seed production	MR de la Peña	70%	148,500	
7	Pilot testing of mud crab hatchery technology	ET Quinitio	90%	232,053	
8	Production of mud crab <i>Scylla serrata</i> juveniles in different nursery systems	MEM Rodriguez	90%	237,500	
9	Mud crab <i>Scylla serrata</i> culture using formulated diet in brackishwater ponds	ET Quinitio	25%	169,996	
10	Grow-out production of the mud crab <i>Scylla serrata</i> in mangrove pens	JM Ladjá	25%	—	
11	Technology validation of the pen culture of mud crab (<i>Scylla serrata</i>) in mangroves	DD Baliao	For approval by Land Bank	—	Land Bank of the Philippines
Shrimp Domestication Program					
12	<i>Penaeus monodon</i> broodstock development: I. Studies on improvement of maturation of pond-reared <i>Penaeus monodon</i> broodstock	FDP Estepa/(ET Quinitio)	10%	473,377	
13	<i>Penaeus indicus</i> / <i>P. merguensis</i> broodstock development: I. Refinement of broodstock management and larval rearing of <i>P. indicus</i> / <i>P. merguensis</i>	FDP Estepa	25%	334,365	
14	Intensive production of <i>Artemia</i> biomass in ponds	MEM Rodriguez	Discontinued	150,861	
15	Vermimeal (<i>Eudrilus euginae</i>) as fish meal substitute in diets of shrimp and milkfish	MR Catacutan	10%	130,200	(TECHNICOM, DOST), Philippines
16	Prawn modified-extensive culture using environment-friendly scheme	EB Coniza	Discontinued	325,396	
17	Improvement and modification of culture techniques for <i>Penaeus indicus</i> using SEAFDEC/AQD's formulated shrimp diets in an environment-friendly scheme	NV Golez	4%	707,540	
18	Seed production for high-value crustaceans, finfishes and mollusks in concrete, canvass and fiber glass tanks	CMV Ganancial	Completed		
19	Enabling aquatic animal health capacity through geographic information system (GIS): Diseases of crustaceans	CL Pitogo	50%	414,897	
Marine Fish Program					
20	Verification studies on the seed production techniques of milkfish and rabbitfish	FG Ayson	30%	914,598	
21	Verification studies on the seed production techniques of high value marine fish species such as grouper, red snapper and sea bass	FG Ayson	30%	1,357,579	

STUDY TITLE		STUDY LEADER	PERCENT COMPLETION	B U D G E T SEAFDEC	EXTERNAL	COLLABORATING UNIT
22	Refinement of techniques, pilot scale operations, and feasibility of marine finfish seed production	DR Chavez	Discontinued	3,528,791		
23	Identification of growth factors as molecular markers for egg quality in cultured marine species	J Bangcaya-Gonzaga	75%	423,951	402,989	ACIAR
24	Use of SEAFDEC formulated diet for milkfish cultured in marine cages (Verification Study)	NB Sumagaysay-Chavoso	50%	249,790		
25	Milkfish fingerlings production in ponds	EB Coniza	10%	180,590		
26	Verification study on the effect of metaldehyde on snail population in milkfish grow-out culture ponds	JM Ladja	25%	72,052		
27	Modified extensive grow-out culture for milkfish in brackishwater ponds	JM Ladja	Completed	115,579		
28	Polyculture of milkfish and siganid in ponds	JM Ladja	95%	84,270		
29	Grow-out culture technique for the production of grouper <i>Epinephelus fuscoguttatus</i> in ponds	JM Ladja	30%	318,778		
30	Culture of humpback grouper, <i>Cromileptis altivelis</i> in floating net cages	REP Mamauag	50%	182,370		
31	Culture of tiger grouper, <i>Epinephelus fuscoguttatus</i> in floating net cages	REP Mamauag	60%	173,900		
32	Verification of grouper/snapper grow-out diets in cages in ponds	EB Coniza	15%	271,610		
33	Verification of sea bass grow-out diets in ponds	EB Coniza	15%	154,790		
34	Net cage culture of sea bass in ponds	KG Corre	New	166,000		
35	Nursery cage culture of grouper (<i>Epinephelus</i> spp.), sea bass (<i>Lates calcarifer</i>) and mangrove red snapper (<i>Lutjanus argentimaculatus</i>) in earthen ponds	RSJ Gapasin	New	97,900		
36	Seed production of SEAFDEC/AQD saline-tolerant tilapia (<i>Oreochromis</i> spp.) in concrete and canvass tanks	CMV Ganancial	Completed	54,119		
37	Grow-out production technique in the culture of milkfish and tilapia in brackishwater ponds	CMV Ganancial	Completed	54,035		
38	Grow-out production technique of grouper, <i>Epinephelus</i> spp. in floating net cages	DD Baliao / NRS Jamon	Completed	225,626		
39	Grow-out production technique of grouper (<i>Epinephelus</i> spp.) in brackishwater ponds	DD Baliao / NRS Jamon	Completed	158,612		
40	Technology validation of the culture of groupers (<i>E. coioides</i>) in floating net cages	REP Mamauag	5%			Land Bank of the Philippines
41	Aquaculture Consultancy Project in Ngatpang State in Palau	DD Baliao/JEA Basco	Completed	2,015,925		Ngatpang State, Palau
42	Reproductive and larval performance of rabbitfish <i>Siganus guttatus</i>	H Ogata/DR Chavez	Completed	163,359		JIRCAS
43	Evaluation of some nutritional and microbial derivatives as immunostimulants in grouper, <i>Epinephelus coioides</i> . I. Influence of environmental stress on innate immunity and resistance to bacteria in grouper fed various immunostimulants	EC Amar	50%	86,400		UP in the Visayas (UPV)
Seaweed Strain Improvement Program						
44	Propagation of <i>Kappaphycus</i> plantlets from callus-like structures by tissue culture	AQ Hurtado	20%	254,000		
45	Strain improvement of farmed carrageenan-producing marine macroalgae	RC Salvador	90%		1,008,000	NFRDI
46	Seed production of <i>Kappaphycus</i> : A protoplast isolation and sporulation of <i>Kappaphycus</i>	MRJ Luhan	10%	243,000		
Smallholder Freshwater Aquaculture Program						
47	Improvement of fillet yield in Nile tilapia (<i>Oreochromis</i> spp) through farm-based mass selection	RV Eguia	40%	137,940		

STUDY TITLE	STUDY LEADER	PERCENT COMPLETION	B U D G E T SEAFDEC	EXTERNAL	COLLABORATING UNIT
48 Economic viability of pilot-scale operations for the production of freshwater fish seedstock or bioeconomics of multispecies freshwater fish hatchery operations	RV Eguia	Discontinued		712,000	ABCDEF,Inc.
49 Refinement of broodstock and hatchery management methods for the commercial production of freshwater prawn <i>Macrobrachium rosenbergii</i> seedstock I. Production of <i>M. rosenbergii</i> larvae tolerant to reduced salinities	RV Eguia	40%	135,390		
50 Refinement of broodstock and hatchery management methods for the commercial production of freshwater prawn <i>Macrobrachium rosenbergii</i> seedstock II. Bioeconomics of freshwater prawn hatchery production in different larval rearing systems	MA Laron	30%	93,500		
51 Refinement of broodstock and nursery technology for the commercial production of bighead carp <i>Aristichthys nobilis</i> (Richardson) fingerlings in cages in Laguna de Bay. 1. Reproductive performance and fry production of bighead carp on different feeding regimes	MA Laron	25%	192,748		
52 Economic impacts of aquaculture development in Laguna lake	DC Israel	40%	612,400		
53 Growth and survival of Asian catfish fry reared in net cages with and without supplemental feeding in Laguna de Bay, Philippines	AD Evangelista	25%	195,292		
54 Production of milkfish <i>Chanos chanos</i> fingerlings from fry in small freshwater ponds and modular lake-based cages in Laguna de Bay, Philippines	MLC Aralar	Discontinued	469,484		
55 Farming of the <i>Macrobrachium rosenbergii</i> in modular cages in Laguna de Bay	MLC Aralar	35%	101,852		
56 Hatchery seed production of the native catfish, <i>Clarias macrocephalus</i>	AC Fermin	8%	206,230		

REGIONAL PROGRAMS

Promotion of Sustainable Aquaculture in the ASEAN Region

57 Morphometric characterization and performance evaluation of <i>Macrobrachium rosenbergii</i> stocks and other commercially important freshwater prawns in the Philippines I. Collection, identification, and validation of <i>Macrobrachium</i> samples II. Reproductive efficiency of two <i>Macrobrachium</i> stocks at different protein levels	MRR Eguia	97%		254,500	ASEAN-GOJ-TF
58 Morphometric characterization and performance evaluation of <i>Macrobrachium</i> strains and other commercially important freshwater prawns in the Philippines C. Performance of different strains of <i>Macrobrachium</i> in grow-out culture in lake-based cages and ponds	MLC Aralar	30%		254,500	ASEAN-GOJ-TF
59 Genetic characterization of commercially important Philippine stocks of freshwater prawn, <i>Macrobrachium</i> sp., using DNA markers	MRR Eguia	45%	181,800	254,400 290,400	ASEAN-GOJ-TF Biotech
60 Development of specific pathogen free (SPF) shrimp (<i>P. monodon</i> , <i>P. vannamei</i>) broodstock: Information exchange on status of <i>P. monodon</i> captive broodstock development in the Southeast Asian region and the possible impact of the introduction of <i>P. vannamei</i> in the region	FDP Estepa	5%		50,900	ASEAN-GOJ-TF
61 Development of specific pathogen free (SPF) shrimp (<i>P. monodon</i> , <i>P. vannamei</i>) broodstock: Genetic characterization of <i>P. monodon</i> broodstock	MRR Eguia	10%		227,836	ASEAN-GOJ-TF
62 Development of specific pathogen free (SPF) shrimp (<i>P. monodon</i> , <i>P. vannamei</i>) broodstock: <i>Penaeus monodon</i> broodstock development: Studies on improvement of maturation of pond-reared <i>Penaeus monodon</i> broodstock	ET Quintio	2%		179,363	ASEAN-GOJ-TF

Disease Surveillance System for Aquatic Animals

63 Epidemiology of the white spot syndrome virus (WSSV) in different shrimp (<i>Penaeus monodon</i>) culture techniques in the Philippines	EA Tendencia	5%		251,300	GOJ-TF
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STUDY TITLE		STUDY LEADER	PERCENT COMPLETION	B U D G E T		COLLABORATING UNIT
				SEAFDEC	EXTERNAL	
64	Surveillance of emerging fish viral pathogens in some Southeast Asian countries	GL Po	60%		1,015,252	GOJ-TF
65	Monitoring and surveillance of transboundary pathogens in cultured shrimps and freshwater prawns	CL Pitogo	50%		703,640	GOJ-TF
66	Screening of important viral diseases of aquatic animals	LD de la Peña	95%		301,560	GOJ-TF
67	Development of control methods for viral nervous necrosis (VNN) of marine fish	LD de la Peña	95%		301,560	GOJ-TF
68	Development of immunological preventive methods for shrimp. I. Immunostimulation and vaccination strategies for WSSV prevention	EC Amar	65%		251,300	GOJ-TF
69	Control of luminous bacterial disease of tiger shrimp with finfish and other aquaculture species	EA Tendencia	Completed			GOJ-TF
70	Chemical and drug residue in marine and aquaculture fish and fish products and their environment: Activity 2.2. Regional survey of pesticide residues in fish and fish products and their environment	EA Tendencia	40%		178,200	SEAFDEC MRFD
71	Chemical and drug residue in marine and aquaculture fish and fish products and their environment: Activity 4.1 Study on the withdrawal period of antibiotics used in aquaculture shrimps and fish	EA Tendencia	20%		320,805	SEAFDEC MRFD
72	Chemical and drug residue in marine and aquaculture fish and fish products and their environment: Activity 5.1. Survey of chloramphenicol and nitrofurans in Southeast Asian fish and fish products	EA Tendencia	50%		178,200	SEAFDEC MRFD
Stock Enhancement for Threatened Species of International Concern						
73	Abalone fishery in Western Visayas and refinement of abalone seeding strategies for stock enhancement	RJ Maliao/MJH Leбата-Ramos	10%	113,500	311,511	GOJ-TF
74	Behavioral studies of the donkey's ear abalone, <i>Haliotis asinina</i> , under laboratory conditions: implications to stock enhancement	SM Buen-Ursua	20%		384,338	GOJ-TF
75	Stock enhancement of true giant clam (<i>Tridacna gigas</i>) in Panay and Negros Islands through seeding of hatchery-produced seeds	RJ Maliao/MJH Leбата-Ramos	60%	77,000	357,499	GOJ-TF
76	Seed production of true giant clam (<i>Tridacna gigas</i>), for stock enhancement	RJ Maliao/ MJH Leбата-Ramos	5%	400,000		
77	Socioeconomic analysis of stock enhancement of abalone and giant clams in Sagay Marine Reserve in the Philippines	ND Salayo	5%	114,480	84,680	GOJ-TF
78	Population dynamics, breeding and seed production of seahorses	RJ Maliao/MJH Leбата-Ramos	10%	—	—	
Other Projects						
79	Comparison of characteristics of KHV isolates from Asia	GL Po	50%		1,196,045	FRA, Japan
80	Screening of alternative lipid sources for aquaculture feeds: Phase I. Extraction and characterization of lipid and fatty acids from plant oils. Phase II. Diet incorporation and feeding experiments on aquaculture species	IG Borlongan	New		124,300	Biotech (NFRDI)
81	Chemical and fish extract-based reduction of phytic acid in plant seed protein for Nile Tilapia (<i>Oreochromis niloticus</i>) feed formulation	RGG Ledesma	85%			NFRDI, Philippines
82	Polyunsaturated fatty acids as useful compounds in aquaculture and human nutrition	JM Oclarit	80%		1,302,828	Mindanao State University (MSU)
			TOTAL:	PHP 19,047,008	11,307,460	
			GRAND TOTAL:	PHP	30,354,468	

Initiating a milestone: a dream project on aquaculture

S EAFDEC/AQD started in 2006 a major activity that translates its technologies into applicable solutions to problems of sustainable aquaculture in coastal communities. At the same time, this effort addresses related issues on job generation and food security in these communities.

SEAFDEC/AQD calls this activity its “dream project” on aquaculture. Officially titled “*Institutional capacity development for sustainable aquaculture*,” the overall goal of this project is to empower aquatic resource users by providing them knowledge to become efficient managers and prudent users of their resources.

It is to be noted that SEAFDEC/AQD is no stranger to this type of project. In 1991-1995, its partnership with the local community of Malalison Island off Panay in west central Philippines successfully demonstrated its team effort and scientific expertise in implementing its first community-based coastal resource management project.

From this experience, SEAFDEC/AQD researchers observed that an empowered fishing community backed by aquaculture technical expertise and local government support could improve its lot. Thus, this partnership enabled the community to manage its fishing resources through its own formulated regulations. Coral reefs were rehabilitated, fish sanctuaries were protected and fish catch improved.

Two local government units (LGU) in the Philippines are collaborating with SEAFDEC/AQD in implementing the “dream project.” These are the provinces of Antique and Capiz in Panay Island.

In May 2006, Antique Congressman Exequiel Javier requested technical assistance from SEAFDEC/AQD on a possible project. The next month, Capiz Governor Vicente Bermejo made a similar request.

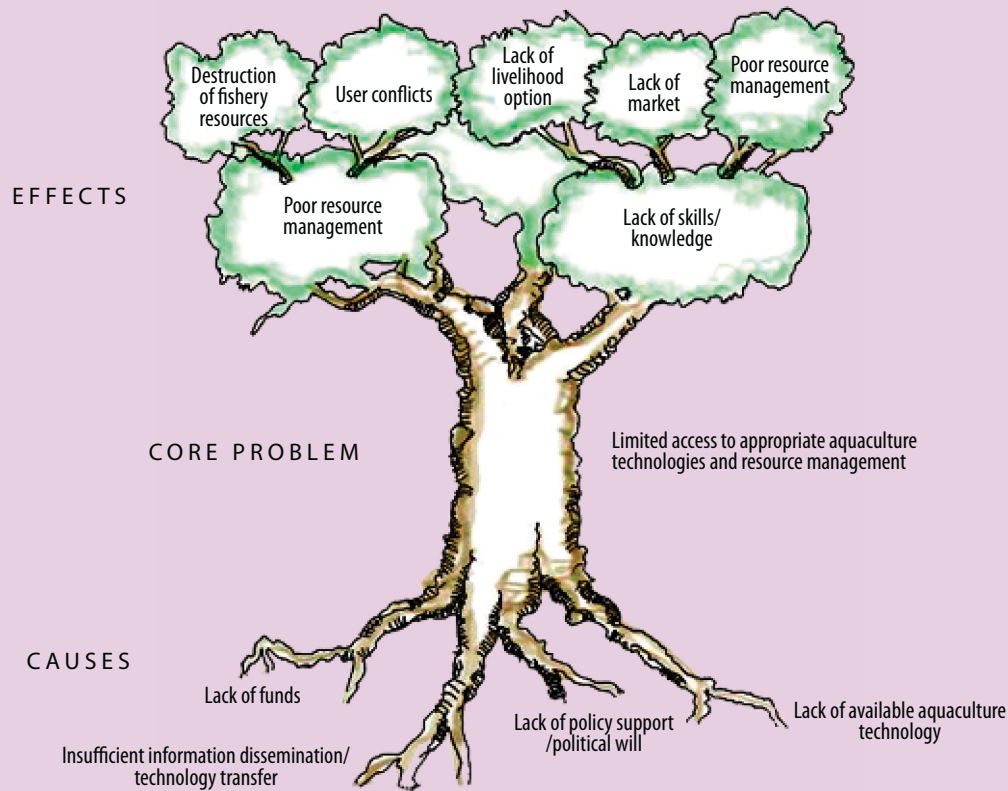
SEAFDEC/AQD scientists then visited the sites and interviewed key informants on their needs. In Antique, information gathered from these activities were validated at the 18-19 July meeting of SEAFDEC/AQD staff and community leaders of the big three Antique groups called LIPASECU (northern towns’ grouping), CAM-CRAME (central) and COAST-HAVEN (southern).

In subsequent meetings, SEAFDEC/AQD researchers, community leaders, local government officials, extension workers, and representatives of non-government and peoples’ organizations and academic institutions continued determining their needs through a problem tree analysis. The subsequent discussions were used as a basis for designing the project proposal.

The agreements were then signed, and provisions for budget, timetables, and responsibilities of partner agencies were spelled out.



SEAFDEC/AQD's aquaculture dream projects in Capiz and Antique provinces: the formal agreement detailing responsibilities of the two sides, provision of funds, and the subsequent training and technology application.



Problem tree analysis, Antique Province, Philippines.

Project Activities

With an initial US\$10,000 fund provided by the Antique Province's Countryside Development Fund, the project has conducted three on-site training and technology demonstration sessions on:

- 1) Sea bass culture in ponds and cages in Hamtic town, conducted on 02-04 August with 10 technicians participating. First harvest of sea bass is expected in early 2007.
- 2) Sea bass and seaweed culture in Pandan town, training conducted 20-22 September with 28 cooperative members. First harvest of sea bass is to be done in March 2007.
- 3) Mud crab culture in Tibiao and Barbaza towns, training conducted 21-24 November with 18 teachers, students, and laborers

The Polytechnic State College of Antique is the project's partner for collaborative research on freshwater hatchery and mud crab culture in ponds

In Capiz, the project operates with US\$53,200 provided by the Capiz Provincial Government through the Office of the Provincial Agriculturist.

Project activities include fishery resource management, R&D work on the angelwing clam (*Pholas orientalis*), and pond culture of sea bass, grouper, mud crab and siganids. The partner academe is Capiz State University. Training will start in January 2007.

Impact evaluation of the projects will be conducted in late 2007 for Antique and late 2009 for Capiz. This will include biophysical, socio-economic, and institutional analyses.

Strategic Partnership

SEAFDEC/AQD researchers operate within a strategic partnership with the local government units. They consider this as the key strategy in the project implementation.

As a key partner in the project, the Antique and Capiz LGUs have demonstrated their willingness to invest in the project, especially in developing a critical mass of adequately trained local technicians who will promote sustainable aquaculture in their respective areas. For its part, SEAFDEC/AQD takes the lead in technology transfer, information support and training of local people.

While the present testing ground of the project is Panay Island in the Philippines, SEAFDEC/AQD proposes expansion of the dream project to Indonesia and Cambodia. The project is also open to other SEAFDEC member-countries who have signified their interest.

2006 Research Highlights: Departmental Programs

Integrated mollusk production program

SEAFDEC/AQD has been developing the technology for controlled hatchery seed production and culture of the tropical abalone, *Haliotis asinina*. Research activities have produced significant results in consistent spawning of captive broodstock year-round, and improved larval settlement and survival.

The main objective of the Integrated Mollusk Program is to develop and demonstrate economically viable abalone production technologies and make abalone production an important industry in suitable coastal communities.

Specifically, the program aims to:

- 1) refine techniques on broodstock management and spawning of captive spawners
- 2) improve seed production technology by enhancing the growth of diatoms, a natural food favored by the abalone, and by understanding the role of microbial communities in the survival of newly settled larvae
- 3) compare the economic viability of producing advanced juveniles in tanks and sea cages set in open waters and develop a viable technology package for the intermediate nursery culture of abalone
- 4) develop a technology package for seed production and grow out of abalone.

In addition to abalone, studies on fishery and biology, as well as hatchery seed production techniques of indigenous mollusk species such as the angelwing *Pholas orientalis* and sea cucumber *Holothuria* sp., will be conducted. This program supports the ASEAN FCG Program on Stock Enhancement for Threatened Species under International Concern by providing hatchery-produced juveniles as seeds for stocking.

The program has four components:

- 1) broodstock management and breeding to refine the spawning and egg and larvae production techniques
- 2) primary nursery rearing and natural food production to improve larval settlement and metamorphosis, increase early juvenile production and develop protocols for sufficient natural food (mainly epiphytic diatoms) production



The abalone
Haliotis
asinina.

- 3) intermediate nursery culture to develop a rearing technology package for juveniles and to assess its economic viability under land-based nursery tank systems as well as in floating net cages in open waters
- 4) grow-out culture in bottom-set and suspended cages to demonstrate the technical and economic viability of abalone marketable-size production.

Refinement of seed production techniques for abalone

The SEAFDEC/AQD hatchery currently maintains a total of 700 wild-caught and hatchery-bred broodstock (198 males, 502 females) in flow-through tanks.

Animals are fed seaweed (*Gracilaria*) in *ad libitum* amounts given every 3 days. Size of breeders ranges from 55-85 mm shell length and 60-95 g in body weight.

Spontaneous group spawning occurred at almost weekly intervals that coincided with the lunar phases throughout the year. Spawning could occur successively for as long as 5-6 days in a row.

Total egg/trochophore production for the year was 195.3 million and total veliger larvae produced was more than 86 million. Survival rate from egg/trochophore to veliger larvae varied from 35-70%, with an average of 44%. Total early juvenile production was 175,000 pieces

with 5-10 mm shell length (SL). Juveniles were maintained on the plastic settlement plates for over 90 days. They grew to a 1.42 mm shell length after 30 days and 5.62 mm shell length after 90 days.

A total income of Philippine Pesos (PhP) 264,540 was realized during the year from sale of juveniles and adult abalone

A pilot testing of abalone hatchery technology is currently being conducted in collaboration with the Aquatech Hatchery, a private enterprise in Oton, Iloilo, Philippines. A total of 2.5 million trochophores has been stocked from September to December 2006.

A duplicate of each of these batches was maintained at the SEAFDEC/AQD hatchery for comparison of results on larval settlement and early juvenile production. Results of the 5 trials showed some encouraging findings in terms of juvenile growth. Partial harvests have been done after a shorter rearing period of 70 days as compared to 90 days in the SEAFDEC/AQD hatchery.

Pilot-testing on the propagation and use of diatoms for larval settlement

A pilot test was conducted on the propagation and use of the diatoms *Amphora* sp. and *Navicula* sp. for larval settlement of the abalone.

Higher feeding density and frequency (day 1-day 5, *Amphora* 1,700 cells/ml + *Navicula* 1,100 cells/ml; day 6-day 10, *Amphora* 3,400 cells/ml + *Navicula* 2,100 cells/ml) resulted in a higher settlement rate on day 5 ($8.6 \pm 1.4\%$), day 10 ($5.1 \pm 0.8\%$) and day 15 ($5.46 \pm 1.8\%$) compared to low feeding density and frequency (day 5, $2.9 \pm 0.9\%$; day 10, $2.4 \pm 1.0\%$; day 15, $2.4 \pm 0.5\%$).

The settlement rate ($4.4 \pm 0.5\%$) of day-5 abalone larvae using bigger surface area (216,000 cm², 100 plates) was significantly better compared to larvae stocked in tanks with smaller surface area (75 plates–162,000 cm², 2.7%; 50 plates–108,000 cm², 3.1%).

No significant difference was noted between 50 and 75 plates per tank. At day 10, there was no significant difference in the survival of metamorphosed larvae among treatments (22.3%–100 plates; 21.9%–75 plates; 15.4%–50 plates). However, at day 15, the survival was significantly different among treatments (100 plates–9.7%, 75 plates–6.9%, 50 plates–3.8%).

In another experiment, results showed that juveniles fed a mixture of 50% diatoms + 50% seaweeds had the highest survival (mean: 96%), length gain (mean: 1.24 cm) and weight gain (mean: 1.03 g) compared to juveniles fed with 100% diatoms only (survival, 93.5%;

length gain, 0.66 cm.; 0.25 g) after 90 days of rearing.

On weaning from diatoms to seaweeds, the size of juvenile (2.5 mm, 5 cm, 7.5 mm) did not matter in terms of growth and survival. However, the harvesting procedure was so stressful for size 2.5 mm juveniles and more of them died compared to the bigger ones. Delaying harvest until 7.5 mm shell length would extend diatom feeding which can be more laborious than seaweed feeding. Therefore, harvesting at 5 mm size juvenile is being recommended, thus confirming the soundness of the existing hatchery practice of weaning at 5-8 mm size for seaweed feeding.

Nursery rearing of abalone in land-based flow-through tanks and in floating sea cages

In the tank nursery, abalone juveniles (mean=1.4 cm SL, 0.5 g BW) were stocked at 1,000 (Treatment 1), 1,500 (Treatment 2), and 2,000 (Treatment 3) per cage in three replicates. Based on PVC shelter surface area of 0.46 m², the stocking density/m² equivalents were 2,174, 3,260, and 4,348, respectively.

After 106 days of feeding with *Gracilaria*, juveniles stocked at the highest density grew slower (2.5 ± 0.4 cm SL and 3.9 ± 2.0 g BW) than the other two treatments (2.7 ± 0.9 and 2.6 ± 0.70 cm SL and 5.8 ± 0.40 and 4.4 ± 0.20 g BW).

However, survival ranged from 94 to 96% which was similar for all treatments. Juveniles were feeding at a rate of 22-30% of its body weight during the early days of culture. This decreased to 10-13% during the last week of culture.

Size distribution showed that 40-50% of the stocks had shell size ranges of 30-34 mm for treatment 1, 25-29 mm for treatment 2 and 20-24 mm for treatment 3. Based on the above, a stocking density of 2,000-3,000/m² surface area during the nursery period yielded good results in terms of growth and survival.

In another experiment, two groups of juveniles (mean=17.2 mm SL, 1.0 g BW) were stocked separately in net cages in flow-through tanks and fed either fresh seaweed *Gracilaria* or a formulated feed (25-27% crude protein). After 75 days of rearing, abalone fed seaweed grew bigger (mean SL and BW of 2.9 ± 0.3 cm and 5.5 ± 1.6 g) than juveniles that were offered formulated feed (mean SL and BW of 2.6 ± 0.2 cm and 3.6 ± 0.8 g). Percent survival was also higher in seaweed-fed group (97%) than in the diet fed group (88%).

For sea cage nursery, nine round mesh cages (30 cm high, 60 cm diameter) suspended from a wooden raft

with plastic drum floats were each stocked with 1000 (Treatment 1), 1500 (Treatment 2), and 2000 (Treatment 3) hatchery produced abalone juveniles (1.4 cm SL, 0.5 g BW) with three replicates.

Each cage was provided with cut pvc pipes as shelters with a total surface area of 0.46 m² resulting in stocking densities per square meter of 2,174, 3,260, and 4,348, respectively.

After 108 days, juveniles in Treatment 2 and Treatment 3 grew similarly with mean shell length of 2.8 cm and 2.9 cm, and mean body weight of 5.5 g and 5.6 g, respectively. These shell length and body size data were significantly higher than those of the juveniles in Treatment 1 (mean SL of 2.2 cm and BW of 2.1 g). Survival rates were 87, 55 and 60% for Treatments 1, 2 and 3 respectively. A confirming trial must be conducted to correct the “artificial” mortality caused by improper positioning of the shelters and excessive feeding rates.

Grow-out culture of abalone in floating sea cages

Hatchery-produced abalone juveniles averaging 3.2 cm shell length and 7.7 g body weight were stocked at densities of 250, 500, and 750 abalones per cage with three replicates each.

Circular cages, 60 cm in diameter, made of double-layered plastic screen frame of sliced PVC pipes with a total volume of 0.085 m³ each were used. Shelters were two 60-cm cuts of flattened 3” S500 PVC pipe joined together by crossing each other to obtain a total surface area of 0.61 m² per cage.

Resulting densities per square meter were 408, 817, and 1,225. Cages were suspended from a bamboo raft to a depth of about 2 meters below the water surface. The abalones were fed with *Gracilaria*, given initially at pre-determined amounts. Actual feeding rates were then computed by weighing the remaining amounts and deducting from the initial weight of feed. Feeding at 30-35% of body weight was done every three days.

First monthly sampling was done on 18 December 2006 by measuring 30 abalone samples per replicate cage for shell length and body weight. The experiment is still on going.

Proposed Activities for 2007

Studies will be conducted in the areas of breeding, larval rearing, intermediate nursery (tanks and cages) and grow-out culture (sea cages).



A round mesh sea cage nursery suspended from a wooden raft with plastic drum floats.

Breeding

- 1) Factors regulating spontaneous spawning in captive broodstock
- 2) Synchrony of spontaneous group spawning in captive broodstock
- 3) Environmental manipulation to optimize egg fertilization and hatching
- 4) Determination of criteria for egg quality evaluation
- 5) Development of transport techniques for eggs and larvae
- 6) Effect of formulated diet on egg production, hatching and survival of metamorphosed larvae: A verification study

Larval rearing

- 1) Evaluation of micro-particulate diet as replacement for diatoms
- 2) Optimum illumination and dissolved oxygen levels during larval settlement
- 3) Is larval mortality due to starvation or water quality malfunction?
- 4) Refinement of large-scale diatom production and techniques for its utilization as larval food

Intermediate nursery

- 1) Stocking density and size at transfer in nursery tanks and sea cages
- 2) Diet manipulation: formulated feed and/or seaweeds for juveniles
- 3) Food consumption and feeding behavior of juveniles at different culture environment

Grow-out culture

- 1) Stocking density, optimum cage surface-to-volume ratio, and cage design (mesh cages or plastic barrels)
- 2) Feeding regimes using wild and cultured seaweeds.

Mud Crab Program

The long term objective of the Mud crab (*Scylla serrata*) Program is to develop a viable technology for sustainable production of captive broodstocks and quality seeds.

Specifically, the mud crab program aims to achieve the following:

- 1) test the viability of concentrated microalgae for culture, rotifer feed and acceptability for crab and fish larvae after storage
- 2) improve crab survival through refinement of broodstock management and hatchery rearing techniques
- 3) improve survival of crab instar to juvenile stage through behavioral studies and culture strategies
- 4) reduce the use of fish by-catch in nursery and grow-out culture
- 5) pilot test and package the technology.

The mud crab research activities comprise four components:

- 1) natural food production which includes mass production of microalgae, testing of their viability for culture after storage and their use as rotifer feed, and determination of its acceptability to crab and fish larvae
- 2) seed production which includes studies on refinement of protocols for broodstock management and larviculture of *Scylla* spp.
- 3) nursery studies focusing on verification trials such as provision of adequate nutrition using formulated

diet and 3-dimensional shelters to reduce cannibalism

- 4) grow-out studies to reduce use of fish by-catch as feed for crab culture in ponds and pens.

These activities also support the SEAFDEC Special 5-year Program on Sustainable Fisheries for Food Security in the ASEAN Region.

Cost-effective culture, harvesting and preservation techniques of green microalgae for crab and fish seed production

Four green microalgae, *Nannochlorum* sp., *Chlorella* sp. (SS56 strain, *Chlorella*-like algae from SEAFDEC/AQD's Dumangas Brackishwater Station), *C. vulgaris* and *C. sorokiniana*, were mass produced using an open tank system and examined in terms of their viability and efficiency as feed to rotifers.

Results showed that the four microalgal species were viable 1-4 months after storage in a refrigerator. However, the freshwater microalgal species (*C. vulgaris* and *C. sorokiniana*) had better viability than the marine species (*Nannochlorum* sp. and *Chlorella* sp.).

Higher population growth rate was attained at 5% for *C. vulgaris*, and 10 and 15% for *C. sorokiniana*. The rotifer population was higher in those grown in *C. vulgaris* and *C. sorokiniana* than in *Nannochlorum* sp. and *Chlorella* sp.

Pilot testing of mud crab hatchery technology

The SEAFDEC/AQD-developed mud crab hatchery technology has kindled a growing interest in the private sector to adopt the technology. A pilot test was conducted in two hatcheries in the Philippines - one in Initao, Misamis Oriental and the other in Roxas City, Capiz.

In the Misamis Oriental hatchery, the initial run recorded a 2.5% survival rate from zoea to megalopa and 59% from megalopa to crab instar (ca. 1.0 cm ICW). After more than two weeks, there was a reduction in the population due to cannibalism. Nursery facilities were not enough to thin out the population. Buyers of crablets were from Samar and Iloilo provinces.

SEAFDEC/AQD researchers are now pilot testing its mud crab hatchery technology. Above is the pilot mud crab hatchery in Capiz province in the Philippines.



In Capiz, the survival rate of the three runs ranged from 1.0-3.8% from zoea to megalopa and 21.0-46.4% from megalopa to crab instar (ca. 1.0 cm ICW). Megalopae and crab instar were nursed in net cages installed in brackishwater ponds until juvenile stage (>2 cm ICW) and then released in grow-out ponds adjacent to the hatchery site.

The shortage of natural food and presence of luminescent bacteria at the zoea stage were the major problems encountered. Selective harvesting of marketable size crabs was conducted in the first batch of juveniles that were grown in ponds.

Refinement of broodstock management and seed production techniques

Broodstock. Reproductive performance of adult mud crabs from Capiz, Philippines was tested in indoor and outdoor concrete tanks with sand substrate.

After three months, crabs held in outdoor tanks had better reproductive performance (latency period from ablation to spawning, duration of embryonic development, number of zoeae/hatching) than those in the indoor tanks.

Larvae. Larval performance was compared using the following schemes:

- 1) Treatment 1 (control) – daily water change + *Nannochlorum* sp. at 50×10^3 cells/ml
- 2) Treatment 2 – water change every 5 days + *Nannochlorum* sp. at 50×10^3 cells/ml
- 3) Treatment 3 – water change every 5 days + *Nannochlorum* sp. at 100×10^3 cells/ml
- 4) Treatment 4 – recirculating water starting at zoea2 + *Nannochlorum* sp. at 50×10^3 cells/ml.

Results showed that the highest survival from zoea1 to megalopa was obtained in Treatment 3 (6.7%) followed by Treatment 2 (5.3%) and Treatment 4 (1.6%). Treatment 1 had the lowest survival (1.6%). Larval stage index was similar in all treatments.

In another study, water was aged for 3 and 5 days after water treatment (15 ppm chlorination for 24 hours and deactivation of chlorine with sodium thiosulfate) prior to use for larval rearing of zoea to megalopa. Water used within 24 hours after treatment served as the control.

Survival was comparable in the control (5.2%) and the 3-day aging treatment (5.2%), and lowest in the 5-day aging treatment (2.6%). Larval stage index was comparable among treatments. Water temperature ranged

from 27 to 30°C. Ammonia levels ranging from 1.03 to 1.65 ppm decreased to 0.14-0.89 ppm in all treatments after water change in the first week of culture. However, no definite pattern was observed among treatments in the second week until the end of the experiment. Nitrite was detected starting at the 13th day of culture. There was no apparent trend in the bacterial counts in the rearing water.

A study was also done to evaluate the application of microalgae in the rearing water using the following concentration: *Tetraselmis tele* ($5-10 \times 10^3$ cells/ml), *Chaetoceros calcitrans* ($30-50 \times 10^3$ cells/ml), *Skeletonema tropicum* ($30-50 \times 10^3$ cells/ml), and *Nannochlorum* sp. (100×10^3 cells/ml).

After 16 days, average survival of zoea1 to megalopa was highest in groups where *T. tele* (23.3%) was added to the rearing water, followed by *C. calcitrans* (15.1%), *Nannochlorum* sp. (8.9%) and *S. tropicum* (8.1%).

Larval stage index showed that larvae in *T. tele* treatment reached the megalopa stage faster than those in the three treatments. Ammonia (0-0.05 ppm) and nitrite (0-0.15 ppm) were within the tolerable levels of the larvae.

Juveniles. Two studies were conducted. One studied the differences in the agonistic behavior between juveniles of the three *Scylla* spp.

Displays were categorized into threat, attack, fight, defense, retreat, rest and bury. *S. olivacea* was found to be the most aggressive of the three species, spending significantly more time in displays of threat. *S. tranquebarica* was the subordinate of the three species, spending more time in defense and retreat displays.

The other study assessed the morphological differences, color adaptation and burying behavior between the hatchery-reared (communal or solitary conditions) and wild *S. serrata* juveniles. The frequency and variation of morphological abnormalities (asymmetrical or slightly bent abdominal flap, abnormal pigmentation or slight depression on dorsal carapace) were higher in hatchery-reared than in wild juveniles (extra lateral spines and abnormal pigmentation).

While burying efficiency and frequency were reduced in hatchery-reared crabs as compared to wild crabs, these were mitigated after a 24-hour exposure to sediment in communal hatchery-reared crabs and after 96 hours in solitary hatchery-reared crabs.

These results provide a better understanding of the behavior among the three mud crab species. Information generated from these studies would be helpful in formulating future strategies and stock enhancement activities.

Production of mud crab juveniles in different nursery systems

Survival and growth of hatchery-reared *S. serrata* crab instar nursed in concrete tanks and net cages in earthen ponds were compared. Crab instars (12.6-14.6 mg body weight) were stocked at 30 individuals per square meter in tanks and net cages and were fed mussel meat. After a month, the survival of crabs was higher in tanks (81%) than in net cages (57%).

However, mean body weight and internal carapace width (ICW) was higher in crabs held in net cages (1.5 g body weight; 2.2 cm ICW) than in tanks (0.9 g; 1.7 cm ICW).



Harvest of crab juveniles in net cages.

A follow-up study to address the preference of crab growers for larger juveniles (≥ 3 cm ICW) for stocking in ponds was determined.

After a month, survival of crabs was highest in net cages (69%) followed by lined ponds (54%). Lowest survival was observed in unlined ponds (40%). Mean body weight and ICW were highest in unlined ponds (9.9 g body weight; 3.8 cm ICW) followed by lined ponds (8.6 g body weight; 3.5 cm ICW) and net cages (7.5 g body weight; 3.3 cm ICW). The abrupt change in salinity from 18 to 35 ppt in ponds could have affected survival and growth of crabs.

Grow-out production of mud crabs in mangrove pens

Hatchery-reared mud crabs with average body weight of 8.4 g were stocked in pens with mangroves at

one crab per two square meters. Crabs are being fed mussel meat at 10% of body weight daily with the gradual introduction of formulated diet until 50% of the feed ration is composed of formulated diet.

Results are still being awaited as the experiment is ongoing.

Mud crab culture in brackishwater ponds using formulated diet

A low-cost diet for mud crab was formulated to reduce the use of fish by-catch. Hatchery-reared mud crab juveniles with average body weight of 7.3 g (3.3 cm ICW) were stocked in two pond compartments at 0.33 individual per square meter. Crabs were fed fish alone (T1) or 50% fish + 50% formulated diet (T2) until they attained marketable size (≥ 500 g body weight).

After two months, crabs fed with fish by-catch alone attained average body weight of 99.2 g (8.23 cm ICW) while those fed fish and formulated diet had 101 g body weight (8.2 cm ICW).

Proposed Activities for 2007

The following activities shall be undertaken in 2007:

- 1) Development of technology for preservation and high density culture of microalgae for rotifer culture and larval food
- 2) Domestication of mud crab, including genetic characterization and husbandry
- 3) Refinement of broodstock management and seed production techniques
- 4) Enabling rapid overview of aquatic animal diseases and pathogens in the Philippines using GIS
- 5) Culture of mud crab in nursery cages using formulated diets including determination of feeding levels, and comparison of formulated diets and natural food
- 6) Verification of nursery technology in net cages
- 7) Comparison of hatchery-reared and wild juveniles grown to marketable size in ponds
- 8) Mud crab culture using formulated diet in ponds and mangrove pens to reduce utilization of fish as aquafeed
- 9) Dissemination of hatchery, nursery and grow-out technology through training courses, provision of technical assistance and updating of manuals
- 10) Adoption of hatchery, nursery and grow-out technology

Shrimp Domestication Program

Research on shrimp is particularly focused on three species - *P. monodon*, *P. indicus*, and *P. merguensis*. The specific objectives of the shrimp program are to:

- 1) develop the technology to produce viable *P. monodon* and *P. indicus/P. merguensis* broodstock in captivity and determine the economic viability of such activity
- 2) maintain family lines of these three species
- 3) refine techniques for broodstock management and
- 4) refine techniques and evaluate the commercial viability of *P. indicus* and *P. merguensis* hatchery and grow-out culture.

The two main studies on shrimp focus on the following:

- 1) *P. monodon* broodstock development, which aims at developing a technology for the production of broodstock (size 80 to 100 g) and refining techniques for production of nauplii and postlarvae from captive broodstock
- 2) *P. indicus/P. merguensis* broodstock development, which seeks to improve nauplii production using captive broodstock, refining techniques for larval rearing, and evaluating the economic viability of hatchery operations.

Apart from these two main studies, the program also includes activities aimed at verifying the technologies developed, testing their viability and packaging these for commercialization.

***P. monodon* broodstock development**

Culture of marketable size *P. monodon* (30-50 g body weight) to broodstock size (80-100 g body weight) is being tested in outdoor concrete tanks with sand substrate. Males (36.4 g average body weight) and females (46.5 g body weight) that had been cultured in a farm in Bacolod City, Negros Occidental, Philippines for five months were stocked in 40-ton tanks. After nine months, males attained an average weight of 67.9 g while females had 112 g body weight.

Another batch of *P. monodon* males (44.3 g average body weight) and females (49.9 g body weight) that had been cultured for five months in ponds in Sta. Catalina, Negros Oriental, Philippines attained an average body weight of 74.1 g for males and 83.9 g body weight for females after seven months in tanks.

Females from both batches attained ovarian maturity (Stage 1 to Stage 3) without eyestalk ablation after 4-5 months in tanks. All females were then subjected to eyestalk ablation; however, none has attained full ovarian maturity (Stage 4) to date.

***P. merguensis/P. indicus* broodstock development**

***P. indicus*.** Wild *P. indicus* spawners (6.8 to 16.8 g body weight) collected from Negros Occidental, Philippines were allowed to spawn individually in separate tanks. Eight out of 17 animals spawned viable eggs. Fecundity ranged from 8,000 to 26,000 nauplii/spawner.

Postlarvae (PL10) from each spawner (family) were stocked separately in 10-ton outdoor concrete tanks and reared to 5-10 g body weight size and stocked in two ponds at SEAFDEC/AQD's Dumangas Brackishwater Station.

Survival rates after 2.5 months were 83.4% and 91.4% and body weights ranged from 6-11 g for male



Captive *P. monodon* broodstock with maturing ovary.



***P. indicus* harvest at the SEAFDEC/AQD Dumangas Brackishwater Station, Dumangas, Iloilo, Philippines.**

and 16-25 g for female. These were stocked in half-ton tanks with or without sand substrate.

After a month, 1,000,000 nauplii were produced from this experiment. Percent spawning (35 to 85% per tank) and fecundity (20,000 to 150,000 nauplii/female) did not significantly differ. There appears to be an improvement in the fecundity of the present stocks (F1) from the parental stock.

Transport simulation tests were conducted to reduce or eliminate mortalities experienced during transport of shrimp stocks. *P. indicus* juveniles (8-10g body weight) were used in simulated transport experiments.

Two experiments were conducted. The first trial compared different transport conditions. Juveniles were placed in plastic-lined styrofoam boxes with either

- a) clear water provided with sand substrate;
- b) clear water without sand; or
- c) with water treated with blue food coloring.

Each box was provided with aeration. Survival rates at the end of the 8-hour simulated transport and at 24, 48, and 72 hours after transport were similar (90 to 100% survival) in all conditions.

The second trial was a factorial experiment on transport conditions (with food coloring and no sand sub-

strate, clear water with sand, clear water without sand) and packing/oxygenation method (packed in styrofoam boxes with aeration from battery-operated aerators or packed in tied double plastic bags with oxygen) during a 12 hour simulated transport.

Survival rates of 90-100% immediately at the end of transport and 82-90% at 72 hours after transport were similar in all treatments.

***P. merguensis*.** *P. merguensis*, produced from six wild spawners obtained from Negros Occidental, Philippines were reared to PL40 in the hatchery and stocked in a 40-ton outdoor concrete tank (1.5m depth) provided with sand bottom. The stocking density was reduced by about half every month. After four months, juveniles were seen in tanks, suggesting that animals (8-10g body weight) had spawned but the postlarvae were not immediately noticed.

After five months, body weights ranged from 6-15 g (males) and 11 to 22 g (females). These were used in experiments to test the effect of sand substrate in broodstock tanks.

Adults that had been previously separated by sex were stocked at a ratio of 1 female: 1 male in broodstock tanks with or without sand substrate. After two weeks, sampling showed that more mating occurred in tanks without sand substrate. A total of three mature broodstock were produced in this test, but only two spawned. About 70,000 nauplii were produced. The fecundity observed for this stock ranged from 5,000 to 26,000 nauplii/spawner, while estimated fecundity for the original parental stock was 2,000 nauplii/ spawner.

Juveniles (2-3g body weight) collected from the tanks were stocked in the SEAFDEC/AQD's Dumangas Brackishwater Station ponds and Tigbauan Marine Station tanks. The stocks in the pond were harvested after a month due to the white spot syndrome virus (WSSV) contamination in the Dumangas Brackishwater Station area.

P. merguensis sub-adults (body weight ranging 4-6 g) were also collected from Panguil Bay, Philippines. These were further grown in tanks and mated with stocks from Negros Occidental, Philippines.

Intensive production of *Artemia* biomass in ponds as shrimp food

Tetraselmis sp. was cultured in a 12-ton outdoor concrete tank. *Artemia nauplii* were stocked at 50 individuals per liter when the algae reached the peak density. Two

runs were conducted using the Hudson Bay and Vietnam *Artemia* strains.

Results showed that poor production of cysts and nauplii was brought about by bad weather conditions. Stocking of *Artemia* in the tank was done as a preliminary activity prior to pond stocking.

Improvement and modification of culture techniques for *P. indicus*

Culture of white shrimps at a stocking density of 28 shrimps per square meter was done in two pond units in SEAFDEC/AQD's Dumangas Brackishwater Station. These ponds were stocked with milkfish and siganids as bio-manipulators.

The same environment-friendly technology and schemes used in *P. monodon* grow-out culture were employed to compare the efficiency of the two SEAFDEC/AQD-formulated shrimp diets for *P. monodon* and *P. indicus* as treatments.

The shrimps from the two ponds were found to be positive for WSSV and these were harvested before mass mortality could occur. The total harvest in one pond was 435 kg with a feed conversion ratio (FCR) of 2.4 while the other pond had 899 kg with an FCR of 1.8.

Enabling aquatic animal health capacity through geographic information system (GIS): Diseases of crustaceans

Using archived data from the Diagnostic Service Laboratory and from active surveillance activities in the GOJ Trust Fund Project, the following data have been encoded into Access database file and ArcView 3.3:

- 1) white spot syndrome virus (WSSV)
- 2) bacteriological analysis reports, *monodon* baculovirus (MBV)
- 3) infectious hypodermal and hematopoietic necrosis virus (IHHNV)
- 4) yellowhead virus (YHV)

The GIS database can generate maps and tables with data sorted under specific categories (e.g. province, species, growth stage, disease occurrence, etc.). Traditional forms used in the SEAFDEC/AQD Fish Health Section's Diagnostic Service have been transformed for easy interface with Access database program.

Additional data that have been encoded into ArcView include the brackishwater pond data of the Philippines based on the records of the Bureau of Fisheries

and Aquatic Resources as well as the number and location of shrimp hatcheries.

The maps on file also include the fish disease diagnostic laboratories in the Philippines that are operated by government and private entities, and their levels of capacity.

These maps of spatial distributions and temporal trends of shrimp diseases enable industry stakeholders, scientists, managers, and policy makers having interest in or needing information on this field to obtain a rapid overview of the health status of cultured shrimps.

Shrimp modified-extensive culture using environment-friendly scheme

Shrimp farming can be socially, environmentally and economically sustainable provided that appropriate management practices are adopted. Some of these practices are closed-recirculating system, environment-friendly schemes or reduced stocking density.

Hatchery-bred shrimp fry (PL 18-20) free of bacterial and viral infection and obtained from a commercial hatchery, were stocked at 5 individuals per square meter in ponds using environment friendly schemes. The shrimps were fed with SEAFDEC/AQD formulated diet. However, mortalities were observed after a month. The study was discontinued since the shrimps were found to be positive for white spot syndrome virus (WSSV).

Proposed Activities for 2007

Shrimp research activities to be conducted in 2007 include the following:

- 1) Information exchange on status of *P. monodon* captive broodstock development in the Southeast Asian region and possible impact of *P. vannamei* introduction
- 2) Genetic characterization of wild and captive broodstock
- 3) Domestication of *P. monodon*, including the production of SPR/SPF broodstock
- 4) Domestication of *P. indicus* and *P. merguensis*
- 5) Refinement of husbandry techniques
- 6) Development of grow-out culture for shrimps using environment-friendly/organic farming
- 7) Dissemination of husbandry technology for shrimp through training courses, provision of technical assistance and updating of manuals
- 8) Adoption of husbandry technology for white shrimps.

Marine Fish Program



The Marine Fish Program intends to improve broodstock management, seed production and grow-out production technologies for marine fishes such as the Asian sea bass, grouper, rabbitfish, milkfish and mangrove red snapper. Specifically, the Program aims to:

- 1) develop, refine and package technologies for seed production, nursery and grow-out culture of marine fish
- 2) test the economic feasibility of a single species and multi-species marine fish broodstock and seed production system
- 3) develop and improve formulated diets for hatchery, nursery, grow-out and broodstock of marine fish

- 4) develop test kits that will determine the quality of fish eggs and larvae, and for easy diagnosis of viral nervous necrosis (VNN) in fish.

The program consists of studies on the following:

- 1) breeding and seed production of 5 species of marine fish namely milkfish, rabbitfish, grouper, snapper and sea bass, as well as of seahorses
- 2) potential use of insulin-like growth factor II (IGF-II) mRNA expression as molecular marker for egg quality in fish
- 3) verification studies on the use of SEAFDEC/AQD-formulated larval diets for the hatchery rearing of grouper, snapper, sea bass, milkfish and rabbitfish
- 4) verification studies on the use of SEAFDEC/AQD-formulated diets for the nursery rearing of grouper, snapper and sea bass
- 5) verification studies on the use of SEAFDEC/AQD-formulated grow-out diets for milkfish cultured in marine cages, and for grouper, snapper and sea bass cultured in ponds
- 6) verification study on the use of a low grade metaldehyde to control snail population in milkfish grow-out culture ponds
- 7) demonstration runs for milkfish fingerling production in ponds, grow-out culture for milkfish, rabbitfish and grouper in brackishwater ponds, and grouper culture in floating net cages

The studies on fish seed production focus on the use of SEAFDEC/AQD-formulated larval diets for milkfish, rabbitfish, grouper, red snapper and sea bass. The breeding and seed production of seahorse is in support of future stock enhancement activities.

Verification studies on seed production techniques for milkfish and rabbitfish

The main objective of the study is to extensively use the larval diet for milkfish and rabbitfish formulated by SEAFDEC/AQD in the larval rearing of these two fish species. The purpose is to reduce the use of natural food in the hatchery.

Milkfish. A total of 140 million (M) eggs was collected from March to December 2006. About 91M

of these eggs were viable eggs. Fertilization rate (FR) ranged from 46-97% and hatching rate (HR) at 60-92%. During the larval rearing, SEAFDEC/AQD's milkfish larval diet was used starting on first feeding.

This year marks the first time in the history of milkfish breeding in SEAFDEC/AQD where year round spawning of milkfish was observed. Normally, the natural spawning season of milkfish starts from March and ends in October. This year, however, the milkfish breeders continued spawning in November 2006 until February 2007. The reason for this is still unknown but the unusually warm water temperature during the months of November until February this year could have brought this about.

Rabbitfish. Limited spawning activities were done for rabbitfish because of the limited number of larval rearing tanks available for rabbitfish rearing. Only 5M larvae were produced during the year, mostly from natural spawning. During the larval rearing, SEAFDEC/AQD's formulated diet was also used.

Production/Income. Excess milkfish eggs and larvae were sold to interested private fish hatcheries and milkfish fry were sold mainly to private fishpond operators. For milkfish eggs/larvae, about 18.1M were sold and valued at PhP108,360. For milkfish fry, 1.8M were sold and valued at PhP376,900. The small number of rabbitfish fry produced was sold to private farmers. About PhP 40,325 worth of rabbitfish fry were sold to 3 private farmers in Panay Island, Philippines.

Verification studies on seed production techniques for grouper, red snapper and sea bass

The SEAFDEC/AQD-formulated diets for hatchery and nursery rearing of grouper were used for the three high value marine fish species - grouper, red snapper and sea bass.

The study aimed to reduce the use of natural food in the hatchery, especially the brine shrimp, and to supply the farmers, especially the nursery growers, with fry of these species that were already weaned to artificial diet.

Groupers. The larval diet for grouper was tested for both *Epinephelus coioides* and *E. fuscoguttatus*. The diet was given from the start of first feeding until complete metamorphosis or when the fry reached 1 inch in body length. The diet was classified into six different size classes to suit the mouth size of the larvae and fry.



The SEAFDEC/AQD formulated diets for the grouper feeding study. Diets 1 and 2 were the grouper diets used in the hatchery, with Diet 1 given during days 3-15 and Diet 2 during days 16-30. Diet 5 was given during the nursery stage.

Preliminary trials indicate that grouper fry can be trained to feed on artificial diet when given early during the larval rearing period. The grouper larval diet formulation of SEAFDEC/AQD is nutritionally adequate and is easily accepted by the larvae and fry during the rearing period. Using the larval diet significantly reduced the amount of brine shrimp used in the larval rearing.

A total of 218M eggs was produced in 2006 and about 131M were good eggs. The bulk of the egg production was from *E. fuscoguttatus* (196 M) and few from *E. coioides* (22 M). Egg fertilization rates ranged from 15-99% and hatching rates from 4-100%.

Sea bass. Sea bass egg production for 2006 was done through hormonal induction either by using luteinizing hormone releasing hormone (LHRH) or human chorionic gonadotrophin (HCG). A total of 11M eggs was produced. Fertilization rate ranged from 0.4-94 % and hatching rates from 0-95% with most of the values on the higher side of the scale. The SEAFDEC/AQD-formulated diet was also used during the larval rearing especially in the latter stages of rearing.

Red snapper. Snapper egg production was very minimal because of the limited number of breeders. A total of 2.7M eggs was spontaneously spawned during the year.

Production/Income. Grouper juveniles that were produced in the hatchery were either used in verification grow-out activities in SEAFDEC/AQD's Dumangas Brackishwater Station and Igang Marine Sub-station or sold to private farmers. About PhP 188,580 worth of grouper juveniles were sold to private farmers. In addition, some grouper eggs and larvae were also sold to interested private fish hatcheries (valued at PhP54,100). Most of the sea bass juveniles produced in the hatchery were used in SEAFDEC/AQD's demonstration/livelihood projects in the different local governments in Western Visayas, Philippines, particularly in the provinces of Antique and Capiz. The excess sea bass eggs and fry were also sold to private fish hatchery owners. About PhP216,000 worth of sea bass fry were sold to private farmers during the period.

Population dynamics, breeding and seed production of seahorses

Seahorses from the natural environment are heavily exploited and efforts are underway to help rehabilitate the wild natural resource. One of the strategies seen to repopulate the natural stocks is by stock enhancement. This however, demands that a steady supply of seeds for

restocking is always available. Hence, the development of the breeding and the seed production protocols for this species is necessary. Breeding activities are on-going.

Broodstock for three species of seahorses, namely *Hippocampus barbouri*, *H. kuda* and *H. comes* were acquired from Palawan, Philippines in April 2006. A total of 290 *H. barbouri* (159 male and 131 female), 19 *H. kuda* (10 male and 9 female) and 22 *H. comes* was acquired. The average stretch height (cm) and weight (g) for *H. kuda* were 12 and 7, respectively, whereas, the average stretch height (cm) and weight (g) for *H. comes* were 11 and 6, respectively. A total of 31 broodstock died due to the following maladies: pouch emphysema, flesh erosion disease (FED), internal gas bubble disease (IGBD), and combination of IGBD and FED. IGBD was observed to be the major cause of adult seahorse mortality.

H. comes broodstock produced a total of 8,013 juveniles from 36 spawning events. Pooled survival of juveniles was about 4%.

Insulin-like growth factor II (IGF-II) as molecular markers for egg quality in fish

This study aims to evaluate whether IGF-II gene expression can be used as a marker for egg quality in marine fish species.

This was tested first in grouper and rabbitfish. Egg samples of grouper and rabbitfish from high fertilization and low fertilization rate groups were collected and subjected to IGF-II gene expression analysis using standard molecular biology protocols.

Preliminary data from grouper samples showed significantly higher IGF-II gene expression levels in early embryo from groups of eggs with high fertilization rate compared with groups with low fertilization rate. This suggests the possibility of using IGF-II as basis for determining good quality eggs in grouper. This however, needs to be confirmed by examining more samples. For rabbitfish, more samples from high fertilization and low fertilization groups will still be collected.

Verification of grow-out diets for grouper and snapper in cages inside ponds

SEAFDEC/AQD has likewise developed a practical diet for the grow-out culture of groupers and snappers. In this particular activity, the artificial diet was tested in the culture of groupers and snappers in cages inside ponds. This activity started in October 2006.

Groupers with initial average body weight (ABW)

The seahorse
*Hippocampus
kuda*.



of 6 g and average body length (ABL) of 6.5 cm were stocked in cages inside the pond at a density of 10 pcs/m². They were fed either the SEAFDEC/AQD formulated diet or a commercial diet. Both diets contained approximately 37% protein.

Sampling for growth measurements was done every 15 days. After 60 days of culture, groupers fed the SEAFDEC/AQD diet reached an ABW of 28 g, specific growth rate (SGR) of 2.5% and survival rate of 64%. Groupers fed commercial diet reached an ABW of 27.3 g, SGR of 2.50%, and survival rate of 64%.

Red snappers with initial ABW of 3 g and ABL of 5 cm were also stocked in cages inside the pond at a density of 10/m², and fed the SEAFDEC/AQD formulated diet or a commercial diet. Sampling for growth measurements was done every 15 days.

After 60 days of culture, snapper fed with the SEAFDEC/AQD diet reached an ABW of 18 g, SGR of 3% and ABL 9.9 cm. The snapper fed with a commercial diet had an ABW of 28 g, SGR of 3.7% and ABL of 11.4 cm. Cannibalism was not a problem in snapper culture since survival rate in both groups was 95%.

Verification of grow-out diets for sea bass in ponds

This new activity aims to test the use of the practical diet developed for the grow-out culture of sea bass in ponds. Together with the SEAFDEC/AQD diet, a commercial diet and a polyculture of sea bass with tilapia was tested. In the latter case, the small-sized tilapia served as food for the sea bass. Stocking of sea bass in this study was done on a staggered basis because of the limited availability of uniform sizes of sea bass fry.

Sea bass with initial average body weight (ABW) of 4 g and average body length (ABL) of 4.5 cm were stocked at density of 5,000/ha. and fed either SEAFDEC/AQD-formulated diet or a commercial diet. Sampling was done every 15 days.

After 90 days of culture, sea bass fed the SEAFDEC/AQD diet had an ABW of 100 g, SGR of 3.7% and ABL of 19.2 cm, whereas sea bass fed commercial diet had an ABW of 166 g, SGR of 4.3% and ABL of 21.5 cm.

Another group of sea bass with initial ABW of 2 g and ABL of 4 cm were stocked at the same density as above. After 60 days of culture, sea bass fed the SEAFDEC/AQD diet had an ABW 40 g, SGR of 5% and ABL 13.8 cm whereas sea bass fed commercial diet had an ABW 31 g, SGR of 4.6% and ABL of 12 cm.

Slightly larger sea bass with initial ABW of 8 g and

ABL of 8.7 cm were also used. After 30 days of culture, sea bass fed the SEAFDEC/AQD diet had an ABW of 58 g, SGR of 6.6% and ABL of 16.2 cm whereas sea bass fed commercial diet had an ABW of 64 g, SGR of 6.8% and ABL of 16.9 cm.

In the group that was fed tilapia, sea bass with initial ABW of 4 g and ABL of 4.5 cm were used. Tilapia with ABW of 65 g was stocked at density of 10,000/ha, 70% of which were female and 30% male. After 30 days of culture, sea bass growth increased to ABW of 18 g and ABL 9.7 cm.

Verification study on the effect of metaldehyde on snail population in milkfish grow-out culture ponds

The efficacy of a low-grade form and cheaper metaldehyde to control the snail population in brackishwater milkfish ponds was tested.

Initial snail population in the pond was assessed by quadrat method in 10 different sites of the pond. Initial average population was 3,910 live snails per square meter (89%) and 485 dead snails per square meter (11%).

A preliminary run showed that a live snail population of 91% was reduced to 54% after 3 days in the pond treated with 10% metaldehyde solution. However, an increase in snail population was observed by day 7 (62%) and onward (day 15, 87%).

In the control pond without metaldehyde treatment, a decrease in live snail population from the initial population of 92% was observed on day 3 (SR, 80%) and day 7 (SR, 54%). However, by day 15, snail population has again increased to 65%. During this period, consistent rain and water seepage in the control and treatment ponds were observed.

The activities will be continued in 2007. Because of the possible effect of rain on the population of snails in ponds, two runs will be done, one during the dry season and another during the wet season. In addition, because of the high cost of commercial metaldehyde, treatments using botanical products that have the potential to reduce snail population in fishponds will be included.

Grow-out culture technique for the production of the tiger grouper in ponds

The pond was prepared by drying and treating the soil with lime and ammonium sulfate to eradicate unwanted species. The pond was divided into 3 sections with bamboo slats to allow partial stocking. Juveniles



The SEAFDEC/AQD-formulated diet for milkfish grown in seawater has a slightly higher protein and lipid content. Initial results of one study are encouraging. Milkfish fed the formulated diet seemed to grow faster and appeared fatter (rounded as in the picture) compared with the milkfish that were fed the usual commercial milkfish diet.

(1,294 pieces) of the tiger grouper (*Epinephelus fuscoguttatus*) harvested from the nursery were stocked in one section at a density of 0.5 individual/m². SEAFDEC/AQD-formulated feed was given at a feeding rate of 5% body weight and frequency of feeding was 4 times a day.

Nursery culture of grouper (average body weight of 6g) was done in 1x1x1m, 2x3x1m and 3x3x1m net cages inside a bigger net cage at density of 150-200 pcs per cubic meter for about 36 days until an average body weight of >15g was reached. Fry were fed with SEAFDEC/AQD-formulated diet (46% protein) at 10% feeding rate and feeding frequency of 6 times a day. Sorting to minimize cannibalism was done every 5-7 days.

Due to a manpower problem, survival rate after 36 days was only 33%, ABW of 22g, and SGR of 3.6%. The juveniles were then stocked directly in the pond at a density of 5,000/ha and fed SEAFDEC/AQD-formulated diet at 5% body weight at frequency of 5 times per day. After 100 days of culture, ABW was 51g with SGR of 0.84%. Size range was very high (25-138g).

A second batch of grouper fry (5,000 pieces) was stocked in 2x3x1m, 3x4x1m and 4x4x1m net cages

placed inside a bigger net cage to avoid crab invasion. Stocking density in cages was 130-150 individuals/m³. The fry were fed with SEAFDEC/AQD-formulated diet at 10% feed rate, 6 times a day. The duration of cage culture was shorter than the previous run because of severe cannibalism. Survival rate during cage culture was 80% with ABW of 7g. SGR was 4.3%. Juveniles released in pond showed ABW of 22g with SGR of 1.3% after 85 days of culture.

Use of SEAFDEC/AQD-formulated diet for milkfish cultured in marine cages

The use of the present commercial feed for milkfish grow-out results in high FCR when given to milkfish grown in cages in open waters. The formulation needs to be improved to give a better performance when used in milkfish that are grown in full-strength seawater. Thus, SEAFDEC/AQD formulated a milkfish grow-out diet with higher lipid content. This diet was tested in collaboration with a private milkfish cage operator in Pangasinan, Northern Philippines.

During the first run, 2 units of 18x18x10m marine cages were stocked with 10-25g milkfish juveniles at 60,000 fish per cage (18 fishes/m³). Feeding with commercial feed or SEAFDEC/AQD-formulated diet started October 3, 2006 when average body weights were 43g (for commercial feed treatment) and 34g (for SEAFDEC/AQD-formulated diet).

The SEAFDEC/AQD diet contained higher lipid compared with the regular commercial feed. After 136 days of culture and 94 days of feeding treatment diets, average weight and specific growth rate of fish given SEAFDEC/AQD diet (204g, 1.9%/day) were slightly higher than fish given commercial diet (176g; 1.5%/day). These preliminary results show that higher lipid in the diet has a positive effect on milkfish grown in seawater.

The second run started on November 9, 2006. Fish weighing 5-8g were stocked in two units 18x18x7m cages at 50,000/cage (22 fishes/m³). Fish were also given SEAFDEC/AQD-formulated diet or commercial feed. Average weight in both cages was approximately 38g after 58 culture days (SGR, 3.3%/day).

Milkfish fingerling production in ponds

This new activity makes use of some unutilized ponds in SEAFDEC/AQD's Dumangas Brackishwater Station for the mass production of marketable-sized products. The station's nursery pond A measuring 2,500

square meters was stocked with 30,000 pieces hatchery-bred milkfish fry (21 days old) last 27 September 2006. Nursery pond B (also with a size of 2,500 square meters) was stocked with 70,000 milkfish fry last 12 October 2006. The fry came from SEAFDEC/AQD fish hatchery. After 35 days of culture, milkfish fingerlings were harvested and transferred to transition ponds (48,899 pcs) and some were sold to private fishpond operators.

Modified extensive grow-out culture for milkfish in brackishwater ponds

In this activity, the extensive grow-out culture of milkfish in brackishwater ponds was modified by using slightly higher stocking density and providing supplemental feeding during the later part of culture when the natural food is already exhausted.

Stunted milkfish fingerlings with ABW of 52 g were stocked at a density of 4,000/ha. After 60 days of culture, milkfish attained ABW of 325 g. SGR and survival rate were 2.8% and 98%, respectively.

Polyculture of milkfish and rabbitfish in ponds

The polyculture of milkfish and rabbitfish in ponds was tested. For this, a pond with an area of 0.84 ha was dried, unwanted species eliminated and fertilized to grow *lablab* and *lumut*. Milkfish fingerlings with ABW of 20 g and rabbitfish fingerlings with ABW of 4 g were stocked at 2,000 and 1,000 pcs/ha, respectively. Bi-monthly fertilization was done to bolster the natural food production.

After 60 days of culture, the ABW of milkfish was 232 g and 8 g for rabbitfish. SGR for milkfish was 4.1%. Milkfish were harvested after 70 days of culture with ABW of 296 g and survival of 100%. Rabbitfish grew poorly with ABW of 31 g and SGR of 3.1%. Their survival rate was only 11%.

Culture of tiger grouper in floating net cages

Performance of tiger grouper fed with SEAFDEC/AQD formulated diet in floating net cages was assessed. A total of 900 pieces tiger grouper with an initial average body weight of 77 g was stocked in a 5x5x3 m floating net cage in SEAFDEC/AQD's Igang Marine Substation.

After 51 days of culture, the average body weight

of the stock was 150 g. Performance parameters showed an FCR of 2.4, an SGR of 1.3% BW per day, and a survival of 92%. This indicates that tiger grouper can be cultured successfully in floating net cages using mainly SEAFDEC/AQD-formulated diet.

Culture of humpback grouper in floating net cages

The performance of humpback grouper (*Cromileptes altivelis*) fed with SEAFDEC/AQD-formulated diet in floating net cages was assessed. A total of 497 humpback grouper initially reared in nursery ponds in SEAFDEC/AQD's Dumangas Brackishwater Station was transferred to Igang Marine Sub-Station. Two batches of fry were weaned to feed on artificial diet. It took four weeks to completely wean the humpback grouper to feed on formulated diet.

Performance parameters after 95 days of culture showed an ABW of 104.5 g, FCR of 2.8, and SGR of 0.78% BW per day and a GR of 0.3 g per day.

Proposed Activities for 2007

All the activities initiated in 2006 will be continued in 2007. New activities will be pursued to include activities that will look at the possibility of developing a mass propagation technique for mysids, a good natural food for the hatchery rearing of grouper and a good substitute for *Artemia* biomass.

Cannibalism in carnivorous species is still a problem in the hatchery and nursery. At present, regular sorting of the stocks and separating the big individuals from the smaller fry is the only way to reduce cannibalism in the hatchery and nursery. Understanding the "physiology" behind this cannibalistic behavior may help design strategies to minimize its effect in culture systems.

Prolonging or extending the spawning season of milkfish, red snapper and sea bass beyond their normal spawning season will also be a new activity for the coming years. For year 2007, efforts toward extending the spawning season of sea bass will be initiated.

The yearly regular training course on "Marine Fish Hatchery Operations" will be offered. This will give the trainees the necessary skills to operate a multi-species marine fish hatchery.

In addition, non-formal training courses for nursery and grow-out cultures of marine fish species in ponds or in cages may be offered in response to requests for technical assistance.

Smallholder Freshwater Aquaculture Program

The Smallholder Freshwater Aquaculture Program (SHFAP) being implemented by SEAFDEC/AQD is in line with the thrust of the SEAFDEC Program on Sustainable Fisheries for Food Security in the ASEAN Region.

Some of the activities are in parallel with other existing programs namely, the Promotion of Sustainable Aquaculture in the ASEAN Region under the Sub-Program Freshwater Aquaculture of Indigenous Species.

The objectives of the program are to:

- 1) refine seed production methods of selected freshwater commodities (e.g. giant freshwater prawn, catfish, carp, tilapia and milkfish)
- 2) develop grow-out production techniques for giant freshwater prawn in lakes using cages
- 3) improve production of both the hatchery and grow-out of the aforementioned freshwater commodities
- 4) assess the social and economic impact of aquaculture in the Laguna de Bay region
- 5) verify and commercialize freshwater aquaculture technologies
- 6) disseminate verified freshwater aquaculture technologies through publication of manuals, flyers and the conduct of seminars, workshops and hands-on training.

Growth and survival of Asian catfish fry reared in net cages with and without supplemental feeding in Laguna de Bay, Philippines

Preliminary data showed that growth of native catfish (*Clarias macrocephalus*) fry after 2 weeks of rearing in hapa net cages was highest in those fish stocked at 100



The catfish experimental set-up at Laguna de Bay.

fry/cage receiving an artificial diet (SGR = 12.4%/day; wt gain after 2 weeks = 0.44 g) and in fish stocked at 200 fry/cage without supplemental diet (SGR = 12.1%/day; wt gain after 2 weeks = 0.28 g).

Lowest growth was observed in those fish stocked at 100 fry/cage without supplemental feed (SGR = 8.1%/day; weight gain = 0.23 g). However, survival rate was higher (27%) than those of the fish stocked at 200 fry/cage without supplemental feed. Survival rates were generally higher in catfish fry that received artificial diet (43% at 100 fry/cage and 32% at 200 fry/cage) than in fish reared without supplemental feed (27% at 100 fry/cage and 20% at 200 fry/cage).

Rearing of a new batch of artificially spawned native catfish larvae in preparation for the lake feeding trials is in progress.

Improvement of fillet yield in Nile tilapia (*Oreochromis spp.*) through farm-based mass selection

The selection methods used to produce the genetically improved commercial stocks were complex. These were the combined family selection for genetically improved farmed tilapia (GIFT) and the marker-assisted selection for Genomar Supreme Tilapia (GST). These commercially improved stocks are more expensive. Hence, high seedstock cost indirectly poses constraints on the farmer as he tries to improve efficiency in his farm.

A simple mass selection protocol has been adopted and the scheme is currently being followed. Selected and control lines from F1 generation were set up and are currently being spawned in tanks.

Refinement of broodstock and hatchery management methods for the commercial production of freshwater prawn *Macrobrachium rosenbergii* seedstock I. Production of *M. rosenbergii* larvae tolerant to reduced salinities

This study aims to develop *M. rosenbergii* seedstock that is tolerant to low salinity and/or freshwater and to reduce the cost of freshwater prawn seedstock production.

Several female breeders were spawned and batches of larvae were reared separately in 12 ppt and 6 ppt salinity levels. Postlarvae were harvested from the batches reared in 12 ppt salinity. No larvae survived to the postlarval stage from those reared in 6 ppt salinity. The oldest

stage of larvae which survived in 6 ppt was stage IX. New protocols are currently being tried to improve and attain the study objectives.

Refinement of broodstock and hatchery management methods for the commercial production of freshwater prawn *M. rosenbergii* seedstock II. Bio-economics of freshwater prawn hatchery production in different larval rearing systems

Preliminary results of the first trial showed that freshwater prawn *M. rosenbergii* larvae reared in clear water had an average survival rate of 37.1% compared to 35.2% in the larvae reared in green water. In terms of development, larvae reared in green water took 25 days to reach the postlarval stage while those larvae reared in clear water took 30 days to become postlarvae.

In the second trial, larvae reared in green water had an average survival of 46.6% compared to 39.3% in larvae reared in the clear water system. In terms of post-larval production, the number of larvae reared in green water was higher (58.2 individuals per liter) compared to larvae reared in clear water (49 individuals per liter).

In the green water system, it took larvae 25 days to reach the post larval stage (PL) compared to 33 days for larvae reared in the clear water system.

Farming of the *Macrobrachium rosenbergii* in modular cages in Laguna de Bay

Polyculture nursery trial of bighead carp *Aristichthys nobilis* (BHC) and *Macrobrachium rosenbergii* (FWP) was conducted in small experimental hapa net cages in Laguna Lake, Philippines for two months. The following treatments were used:

- 1) 40 FWP + 40 BHC (40 individuals/m² each of FWP postlarvae and BHC fry)
- 2) 40 FWP + 80 BHC (40 FWP individuals/m² and 80 BHC individuals/m²)
- 3) 40 FWP + 120 BHC (40 FWP individuals/m² and 120 BHC individuals/m²)
- 4) 40 FWP (40 FWP individuals/m²)
- 5) 120 BHC (120 BHC individuals/m²).

Fry mash feed was provided only for *A. nobilis* computed at 10% total body weight. *M. rosenbergii* was fed only with available natural food and was not given any supplementary feed. This was also the case for the monoculture treatment

No significant differences in growth was observed for *Macrobrachium* in all treatments (3.1, 4.0, 3.5, 3.7 g for 40FWP+40BHC, 40FWP+80BHC, 40FWP+120BHC, and 40FWP, respectively).

Aristichthys survival was affected by the treatments with the highest to lowest survival in the following order: 52, 41, 30, 23% for 40FWP+40BHC, 40FWP+80BHC, 40FWP+120BHC, BHC only, respectively. (3.1, 7.8, 6.1, 7.7 g for 40FWP+40BHC, 40FWP+80BHC, 40FWP+120BHC, and 120BHC, respectively)

It should be noted that at the time of the experiment, water quality in the Laguna Lake was generally poor with very high turbidity values. Bighead carp survival was low because of ectoparasitic infestation (*Laernia* sp.) which resulted in overall poor survival of the juveniles.

Economic impacts of aquaculture development in Laguna lake

This study assesses the economic impacts of aquaculture development in Laguna Lake, Philippines over time. A questionnaire has been prepared, pre-tested and finalized for the survey scheduled during the 4th quarter of 2006. Continuous gathering of secondary data and information has been conducted in the institutional source.

Morphometric characterization and performance evaluation of different *Macrobrachium* strains and other commercially important freshwater prawns in the Philippines. II. Reproductive efficiency of two *Macrobrachium* stocks fed diets with different protein levels

Spawning sets (1 male: 5 females) of four-month old *Macrobrachium rosenbergii* from a hatchery stock (BFAR strain, *M. rosenbergii rosenbergii*) and a wild stock (CAL or Calumpit strain, possibly *M. rosenbergii rosenbergii* x *M. dacqueti* F₁s) were placed in replicate 2x2x1 hapa net cages in Laguna Lake, Philippines.

Stocks were fed using the following treatments:

- 1) Treatment A - low protein (commercial fish feed pellets) at 2% of the prawn biomass
- 2) Treatment B - high protein (prawn feed pellets) at 2% of the prawn biomass and
- 3) Treatment C - low protein (commercial fish feed pellets), given *ad libitum*.

Results showed differences in the reproductive effi-

ciency of the two stocks especially in terms of the average number of hatchlings per g female body weight.

BFAR stocks fed low protein fish feed *ad libitum* had the highest number of hatchlings at 648/g body weight followed by those fed fish feed at 2% prawn biomass (583/g) and the high protein prawn feed pellets (578/g).

On the other hand, Calumpit stocks fed low protein fish feed at 2% prawn biomass had the most number of hatchlings per g female body weight (823/g), followed by low protein fish feed administered *ad libitum* (741/g) and finally high protein prawn feed (609/g).

Meanwhile, more *M. rosenbergii rosenbergii* stocks shall be collected from Leganes, Iloilo, Philippines. All these stocks will be temporarily maintained and bred in the SEAFDEC/AQD Tigbauan Main Station for seed-stock production. Postlarvae produced from Leganes and Mindanao stocks from the Mindanao State University shall be brought to the Binangonan Freshwater Station of SEAFDEC/AQD for stock comparison studies.

Refinement of broodstock and nursery technology for the commercial production of bighead carp (*Aristichthys nobilis*) fingerlings in cages in Laguna de Bay. 1. Reproductive performance and fry production of bighead carp in different feeding regimes

Preliminary results during the first sampling showed that female bighead carp broodstock in treatment 1 (one month feeding before spawning) had an average 83.3 % gonadal maturity, followed by treatment 2 (2 months feeding before spawning, 73.3%), and treatment 3 (3 months feeding before spawning, 67.6%).

The lowest percent gonadal maturity in female bighead carp broodstock was in treatment 4 (no feeding); however, for male bighead carp broodstock, percent gonadal maturity was highest in treatment 3 (96.5%), followed by treatment 2 (86.7%), and treatment 1 (80.0%). Lowest percent gonadal maturity was obtained in treatment 4 (40.3%).

Hatchery seed production of the native catfish, *Clarias macrocephalus*

SEAFDEC/AQD has acquired from Palawan, Philippines 227 pieces of native catfish (*Clarias macrocephalus*) broodstock, each weighing about 200-250 g. They are now being conditioned in soil concrete tanks, fed with SEAFDEC-formulated diet. Earlier, 92 pieces of African catfish (*Clarias gariepinus*) each weighing 250 g were acquired. The hatchery will produce pure native catfish,

C. macrocephalus as well as hybrids of *C. macrocephalus* (F) x *C. gariepinus* (M) to compare growth and survival of juveniles, as well as consumer acceptance of marketable size animals.

Proposed Activities for 2007

Research

The research projects described in the previous section shall be continued in 2007.

In addition to these, the following are new proposals for next year:

- 1) *Screening of possible natural products from freshwater microalgae.* Its long-term objective is to identify species of freshwater microalgae with potential for the production of natural products. In the short-term, this study will mass produce various microalgae species in freshwater bodies and evaluate various natural products from freshwater microalgae,
- 2) *Testing the viability of algal beads immobilized in various matrices: Response to different environmental conditions.* This aims to enable the long-term maintenance of microalgae with minimal cost, and to identify the optimal environmental conditions for the viability of immobilized microalgae and
- 3) *Integrated fisheries resource management (Rinconada Lakes, Philippines and NSW Australia).* This is to be conducted in collaboration with the Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) with funding from the Australian Center for International Agricultural Research (ACIAR) through BFAR. The project aims:
 - to facilitate adoption by key stakeholders of management actions to improve management of the Rinconada Lakes in the Philippines,
 - facilitate improved fish cage management to increase economic return and reduce impacts on water quality in the Philippine Lakes Buhi and Bato,
 - effectively manage water hyacinth infestations in the Philippine Lakes Buhi, Bato and Baao-Bula, and
 - document and package ecosystem-based management findings and outcomes of this project for adoption.

Technology verification and commercialization

A 24-month technology verification of hatchery seed production of the native catfish *C. macrocephalus* will be implemented. The project aims to:



- 1) provide seeds for LGU and NGO partners interested in grow-out of native catfish
- 2) serve as catfish hatchery and nursery demonstration farms for Western Visayas, Philippines
- 3) provide technical assistance to fish farmers interested in catfish production.

Another 24-month project is the advanced fingerling production for freshwater fish. It aims to ensure the continuous supply of advanced fingerling stocks of various freshwater species, and to refine techniques for the commercial production of advanced juveniles of various freshwater species to meet the demand for larger seed-stock.

The program will continue its offering and conduct of training courses and the publication of manuals on freshwater commodities.

Technology verification studies and conduct of training courses will continue to be major activities of the smallholder freshwater aquaculture program.

Seaweed Strain Improvement Program



The seaweed *Kappaphycus*.

The Seaweed Strain Improvement Program focuses mainly on two carrageenophytes, *Kappaphycus* and *Eucheuma*, and one agarophyte, *Gracilaria*. The first two genera are the flagship of the seaweed industry of the Philippines, while the latter is still a developing industry.

SEAFDEC/AQD has embarked on strain improvement of *Kappaphycus alvarezii*, *Eucheuma denticulatum* and other economically important seaweeds by using both the vegetative and reproductive explants as mother plants.

The vegetative explant area will employ tissue culture of callus cells, protoplast/cell isolates and fusants while the reproductive explant will utilize spore and spore fusion as sources of 'new' and 'improved' strain through a selection process.

In vitro growth and development and rearing in land-sea based nursery of these young plants will be made. 'New' and 'improved' strains will be subjected to genomic DNA analysis, growth rate performance and carrageenan quality analysis. Only plants showing superior growth rate, carrageenan quality and disease resistance will be further propagated.

Another research area of the seaweed program is bio-remediation. *Gracilaria* and *Kappaphycus* will be used

as biofilters in a semi-intensive shrimp culture in ponds and in fish cages. Earlier reports have shown the capacity of seaweeds to absorb excess nutrients in the water column.

This program aims to:

- 1) regenerate plantlets of *Kappaphycus/Eucheuma* from callus-like structure through tissue culture and mutagenesis; protoplast/spore fusion, and rear the plantlets under laboratory and hatchery conditions
- 2) select regenerants with improved characteristics (fast growth, carrageenan quality and disease resistance)
- 3) optimize the growth of regenerants under ambient conditions
- 4) establish a cultivars' nursery bank in order to provide a sustainable, accessible, and good quality cultivars to seaweed farmers
- 5) replicate the system of producing cultivars in key seaweed production areas of the country.

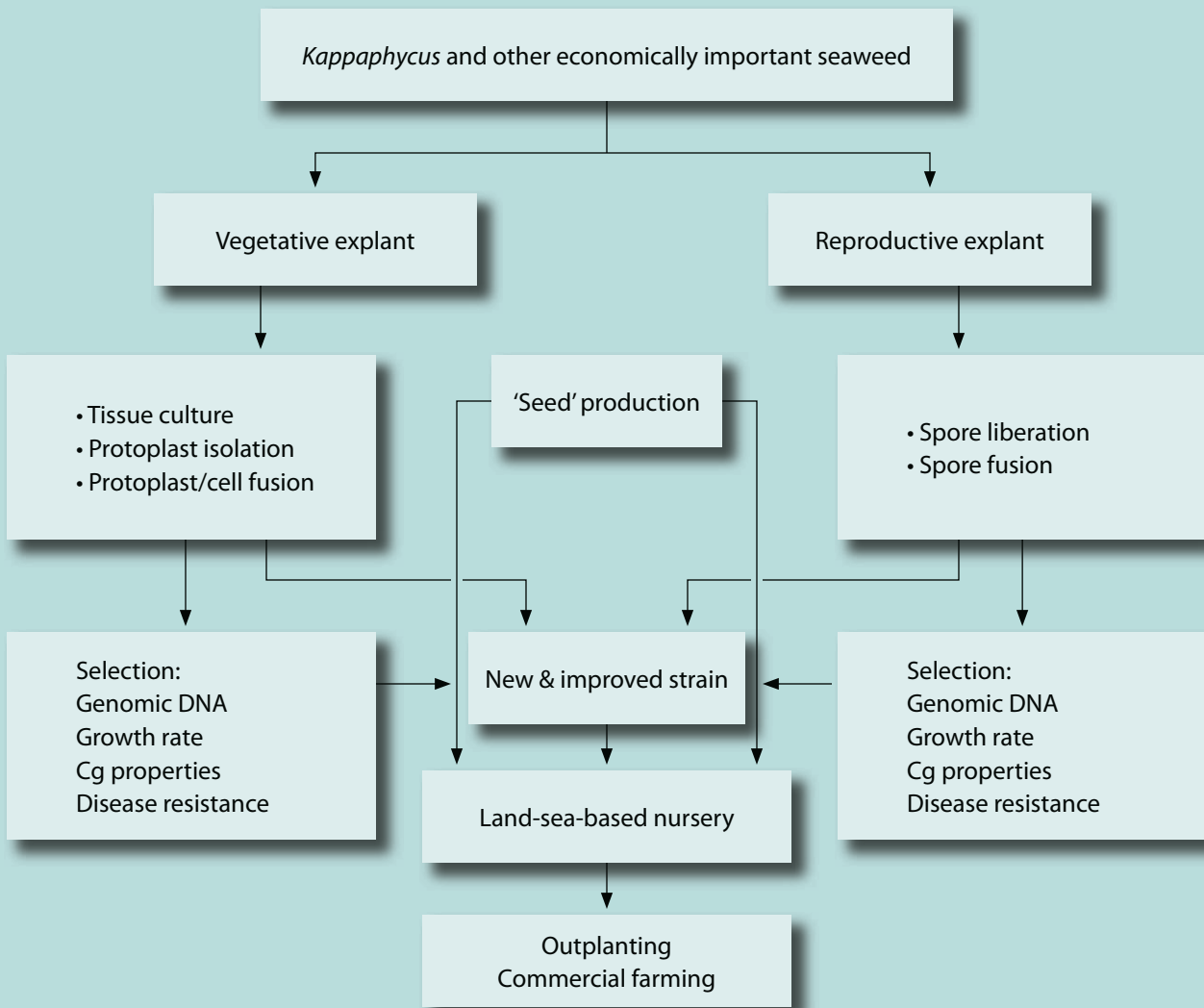
Propagation of *Kappaphycus* plantlets from callus-like structures by tissue culture

Callus cells were released at the medullary layer with the use of ESS/2 + E3 antibiotic + plant growth regulator (PAA + zeatin). Cell division was both anticlinal and periclinal. Callus formation is in progress.

Characterization of carrageenan properties and screening for disease resistance of farmed carrageenophytes

Thirty-two morphotypes/ecotypes of *Kappaphycus* (28), *Kappaphycus* sp.(1) and *Eucheuma* (3) were collected from different seaweed farms in the Philippines. Characterization of carrageenan properties of these cultivars has been completed.

Parent stocks that will serve as starting materials for seedstock production have been chosen based on carrageenan qualities. These will be further subjected to infection and growth experiments to determine disease resistance traits and growth performance. The cultivars chosen were those collected from the provinces of Eastern Samar, Tawi-tawi, Zamboanga, Surigao, Bohol and Palawan.



Strain improvement of *Kappaphycus* and other commercially important seaweeds.

Growth experiments in concrete tanks and growth chambers were conducted to identify which collected cultivars can be cultured in land-based facilities and to develop protocols for land-based seaweed culture.

Initial results showed that *K. alvarezii* cultivars and *Euclima denticulatum* grew well in tanks and growth chambers. Culture collections are maintained in growth chambers, tanks and in the phycology laboratory.

Molecular strategies to characterize and improve farmed carrageenan-producing marine macroalgae

Primer designing and optimization of DNA extrac-

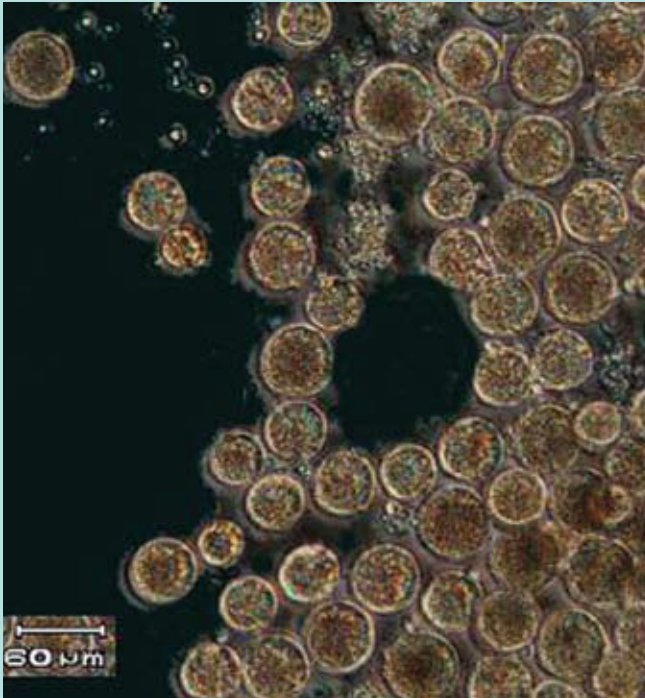
tion have been undertaken. DNA from *K. alvarezii* cultivars collected from seaweed farms all over the Philippines have been extracted and will be subjected to RFLP analysis.

Strain improvement and seedstock production through genetic manipulation

Germlings (<1 cm length) produced from cells are being grown into plantlets in different culture media (f/2, urea, 16-20-0 and urea+16-20-0) at 20 and 25°C temperatures.

Sporelings from a cystocarpic plant grown in a cage in a seaweed farm in Surigao, Philippines have also been

Spores (2N) of *Kappaphycus*.



The growing sporelings at 45 days old.



"Ice-ice"-associated diatoms and bacteria.



produced. After six months, largest plantlet is 10.16 cm (average thalli length). The spores produced and germinated under laboratory condition from two high-yielding cultivars of *K. alvarezii* obtained from Tawi-tawi have disintegrated due to fungal and nematode infection.

Seed production of *Kappaphycus*: Protoplast isolation and sporulation

Protoplasts were isolated from *Kappaphycus* using combinations of the enzymes cellulase and maceroenzyme and gastric enzymes extracted from abalone and siganid.

The spores of *Kappaphycus* were released *in vitro*. More than 50% of the spores that were floating in the water column settled after 3 days. Cell division of the spores occurred 4 days after the spores were released. The dividing cells eventually formed into disks where dome-like structures appeared and developed into shoots or sporelings

"Ice-ice"-associated bacteria were isolated from *Kappaphycus* during the collection of mature plants for sporulation. There were 18 isolates identified in the preliminary test but these were reduced to 7 species of *Vibrio* bacteria on further verification.

The scanning electron microscopy (SEM) images of plant parts with "ice-ice" showed *Thalassiothrix* and *Nitzschia* as the dominant diatom species.

Proposed Activities for 2007

The following activities shall be conducted in 2007:

- 1) Propagation of *Kappaphycus* plantlets from callus-like structures by tissue culture regardless of origin - Plantlet regeneration from callus cells by tissue culture and mutagenesis; hatchery rearing of plantlets; selection of 'new' and 'improved' plants; land-based nursery; out-planting
- 2) Seed Production of *Kappaphycus*: A. Protoplast isolation and sporulation of *Kappaphycus* - Isolation and seed production of protoplasts and spores; genomic DNA of 'new' plants from protoplasts and spores; selection of 'new' and 'improved' plant; hatchery rearing of 'new' plants; isolation of *Vibrio* from 'ice-ice' infected *Kappaphycus*.

Other R&D Projects

Comparison of characteristics of KHV isolates from Asia

This is a project funded by the Fisheries Research Agency (FRA) of Japan. Ongoing since 2004, the project aims to develop methods to prevent and control the *koi* (common carp) herpes virus (KHV) from spreading.

Last year's continuous monitoring of the viability of KHV showed that the virus when stored at -80°C is still viable even after one and a half years of storage.

The comparative susceptibility tests showed that KHV can propagate in KF-1, KT-2, KFC, and NGF3 cells. KF-1 cells yielded the highest titer of $10^{3.50}\text{TCID}_{50}/\text{ml}$ and also gave consistent titers of the virus after prolonged incubation. On the other hand, EPC cells were refractory to KHV.

Sequence analysis of KHV (Malaysian strain) showed that it belongs to a new strain of the European genotype which is classified in this study as E7 strain. The KHV extracts from the Peoples' Republic of China (PRC) and Taiwan fall under the Asian genotype and strains A1 and A2, respectively.

DNA sequence data for the second sample of KHV isolate from Indonesia were compared for similarities with other sequences deposited in GenBank, using NCBI BLASTN 2.2.14 search. Search results showed that the Indonesian KHV isolate was 100% similar to KHV SphI-5 clone of Gray *et al.* (2002) and 99% similar to KHV isolate no. 323909 isolated in New York, USA (Grimmett *et al.*, 2005)

Polyunsaturated fatty acids as useful compounds in aquaculture and human nutrition

Marine sponges, yeasts and thraustochytrids were collected from various sites in the Philippines for screening of polyunsaturated fatty acids (PUFAs) essential to aquaculture species and human nutrition.

Nonpolar fractions of sponge tissue contain considerable amounts of PUFA esters, including docosahexaenoic acid (DHA; $>2.0 \{10^3 \text{ mg/g of WW}\}$), arachidonic acid (ARA; $>4.0\%$ of TFA), eicosapentaenoic acid (EPA; $>9.0 \{10^3 \text{ mg/g of WW}\}$) and docosapentaenoic acid (DPA; $1.0 \{10^3 \text{ mg/g of WW}\}$).

Histological preparations and spicule morphometry further support their classification under the assigned ge-

neric ranks. Microbial symbionts of selected species were classified through cytological, biochemical and molecular analyses. Though devoid of PUFAs, triacylglycerols of marine yeasts contain high amounts of essential omega C18 fatty acids especially C18:1 ω 9 (up to 36% of TFA) and C18:1 ω 6 (up to 21% of TFA).

Compared to sponges and yeasts, thraustochytrids were the most promising for industrial use because they have high lipid yield (15-20% of total biomass of freeze-dried cells) containing long-chained PUFAs including DHA, ARA, EPA, DTA (docosatetraenoic acid) and DPA.

DHA content varies from 23-50% of TFA, depending on the isolate strain, and nutritional and physico-chemical conditions.

Chemical, and fish extract-based reduction of phytic acid in plant seed protein for Nile Tilapia (*Oreochromis niloticus*) feed formulation

A commercial phytase enzyme (5,000 IU/gram) was tested for its efficacy in removing phytate in a soybean seed sample. Preliminary trials were done using Gomori phosphate buffers at pH 5.9, 6.3, 6.7, 7.1 and 7.4 at 25°C .

Results show a variable phytase activity that is pH-dependent. Phytate removal in soybean samples was low at 1-4%.

However, this phytate removal rate can be improved by lowering the enzyme concentration and increasing the seed substrate (Km) to 1 percent from the preliminary 5.6% that was used. Also pH can be lowered to acidic levels below pH 5.9.

The performance of this enzyme can likewise be enhanced by eliminating the use of isotonic solution and substitute water as the solvent for the enzyme. Finally, increasing the temperature in the reaction mixture can lead to better results.

Work is also being done on the tilapia crude enzyme in improving phytate removal. The efficiency of the tilapia crude extract in phytic acid removal will be compared to that of the commercial enzyme obtained in future growth trials using tilapia.

In the meantime, other enzyme characteristics, including their performance under different salinity increments are being studied to test their applicability in feed formulations for freshwater and brackishwater fishes or invertebrates.

R&D Highlights: Regional Programs

Special 5-year Program on Sustainable Fisheries for Food Security in the ASEAN Region, Component II - Aquaculture

The first Aquaculture Component of SEAFDEC's Special Five year Program on Sustainable Fisheries for Food Security in the ASEAN Region was implemented in 2002-2005.

This was in response to recommendations made at the ASEAN-SEAFDEC "Conference on Sustainable Fisheries in the Third Millennium: Fish for the People" which was held in Bangkok, Thailand in November 2001.

While the activities were successfully implemented, member countries identified the need for addressing some research and technology gaps.

Thus, the Planning Workshop for the Special Five-Year Program (Aquaculture Component): 2006-2010 was convened from 30 November to 02 December 2005 in Thailand.

This resulted in a plan of action that would respond to the concerns of the ASEAN countries in freshwater aquaculture of indigenous species, integrated aquaculture systems, coastal aquaculture and mariculture, and captive broodstock development.

The plan of action for 2006-2010 was endorsed for implementation under the ASEAN-SEAFDEC FCG

collaborative mechanism during the 28th Program Committee meeting in Thailand in 2005 and was approved for implementation by the SEAFDEC Council during its 38th Meeting in April 2006.

Following this, SEAFDEC/AQD, in collaboration with member countries, is conducting two projects:

- 1) Development of technologies for sustainable aquaculture
- 2) Human capacity building for sustainable aquaculture

PROJECT 1. DEVELOPMENT OF TECHNOLOGIES FOR SUSTAINABLE AQUACULTURE

This project addresses regionally relevant technology needs for sustainable aquaculture in the areas of broodstock development, genetic improvement, seed production, and culture systems of various priority species for aquaculture mainly through research and verification.

Freshwater aquaculture of indigenous species.

This activity intends to address various priority concerns identified during the February 2005 Planning Meeting.

In order to shorten the research process, countries with common interest in specific species were grouped together to conduct the collaborative research on such species. Countries that have the developed technology for such identified species are to provide technical assistance.

During 2006, the collaborative study on the genetic improvement and seed production of the giant freshwater prawn, *Macrobrachium rosenbergii*, was actively pursued. The objective is to improve the genetic quality and seed production technology to produce good quality seedstocks. The participating countries are Indonesia, the Philippines and Thailand.

M. rosenbergii is the focus of research on freshwater aquaculture of indigenous species in the region.



Two studies were conducted in Indonesia in 2006:

- 1) collection of wild stock from Sulawesi to construct a base population for GI Macro II and another potential population such as those from Kalimantan, Indonesia; and
- 2) evaluation and characterization of GI Macro II, Sulawesi and Kalimantan strains using molecular marker.

Numerous breeders originating from the wild were collected and several pair matings were conducted as part of preparations for establishing a base population to initiate selective breeding.

Characterization using molecular marker, DNA extraction and amplification of mtDNA have been tried.

In the Philippines, morphometric characterization and performance evaluation of different *Macrobrachium* strains and other commercially important freshwater prawns are in progress. Wild samples were collected from Vigan, Oroquieta, Cotabato, and Antique. These were taxonomically identified.

The performance of different strains of *Macrobrachium rosenbergii* in grow-out culture in lake-based cages and ponds is being assessed. Apart from these studies, genetic characterization of *M. rosenbergii* in ASEAN countries is in-progress.

The first batch of wild and hatchery stocks from Luzon, Philippines was collected and methods to PCR-amplify DNA from these samples are currently being optimized. Pleopods from freshwater prawn samples collected from various sources in Visayas and Mindanao will be included in the mtDNA-RFLP analysis.

The studies in Thailand focus on:

- 1) Selective breeding to improve growth and
- 2) Use of allozyme marker to detect genetic variation and growth performance.

In the selective breeding experiment, nine crosses were reared in three environments for eight months. Results after 4 months showed that heterogeneity in body lengths and weights of these crosses ranged between 0.28-10.14% and 2.77-15.47%, respectively.

Stocks from the Aquatic Animal Genetic Research and Development Institute (AAGRDI) and FARM (Petchaburi Farm) were paired and induced to spawn to initiate the parental generation of the selection experiment in Burirum and Uttaradit Fisheries Test and Research Centers.

Parent prawns were also pooled and kept for further genetic diversity analysis. To support the sub-activity on Selective Breeding of the Freshwater Prawn, *Macrobra-*



Shrimp
(P. vannamei)
infected
with Taura
Syndrome Virus
(Indonesia).

chium samples for the genetic variation detection using allozyme marker were taken from the parental stocks from each area.

Integrated aquaculture systems. This activity makes use of successful experiences from other institutions or countries on the integration of aquaculture operations with the farming of rice and other crops in the agricultural systems in the region.

In 2006, the activity focused on the translation of SEAFDEC/AQD's "Manual on Tilapia Farming in Ponds and Cages" into the Indonesian and Myanmar languages.

Coastal aquaculture and mariculture. This focuses on promoting the coastal areas in the region where a range of commercially important aquatic species could be cultured (for example, mud crab, abalone, marine fishes, etc.).

Technologies on small-scale mariculture including offshore cages that are already developed in some countries will be verified in countries where such technology may be appropriate. The following activities have been carried out:

- 1) Grouper seed production. As part of the initial activity to promote grouper seed production in the ASEAN region, economic analysis on grouper seed production in Indonesia was initiated. The study de-

scribes the development of the small-scale backyard hatcheries and their economic structure and benefit to the farmers and local communities in Bali. In 2006, a field survey was conducted in cooperation with the Gondol Research Institute for Mariculture.

- 2) Mud crab seed production and grow-out. The Planning workshop in December 2005 reported the availability of a Vietnamese Manual on Mud crab. This was recommended for translation into English and later into major languages in the region. The translated manual is now being edited.

Captive broodstock development. Activities are currently being conducted on:

- 1) Development of specific pathogen-free shrimp (*P. monodon*, *P. vannamei*) broodstock. Stocks were procured from shrimp farms in Visayas (Philippines), reared separately to broodstock size, and mated.
- 2) Genetic characterization of *P. monodon* broodstock. This involves two sub-activities: genetic characterization of broodstock and improvement of maturation of pond-reared *P. monodon* broodstock. Samples were collected from several areas in the Philippines to initiate genetic characterization.

Proposed Activities for 2007

The following shall be pursued further:

- 1) **Freshwater aquaculture of indigenous species.** The focus of the activity will be on genetic improvement of *Macrobrachium rosenbergii*. Studies will involve evaluation of performance of different strains of *M. rosenbergii* in grow-out culture in lake-based cages and in ponds; and genetic characterization of commercially important Philippine stocks of freshwater prawn using DNA markers.
- 2) **Coastal aquaculture and mariculture.** This will involve the development of strategies to extend the spawning season of sea bass (*Lates calcarifer*) under captivity.
- 3) **Captive broodstock development and seed production**
 - a) Development of specific pathogen-free (SPF) shrimp (*P. monodon*, *P. vannamei*) broodstock. This will include identification of potential sources of good quality tiger shrimp broodstock, development of healthy broodstock from highly genetically variable wild stocks, and effective management and selective breeding of good

quality tiger shrimp (*P. monodon*) with molecular genetic tools (marker-based data).

- b) Domestication of mud crab (*Scylla serrata*). In order to develop a husbandry technology for the sustainable supply of good quality captive broodstock of the mud crab *S. serrata*, two studies will be implemented: (i) Domestication of mud crab and (ii) Genetic characterization of *Scylla* spp. broodstock.

PROJECT 2. HUMAN CAPACITY BUILDING FOR SUSTAINABLE AQUACULTURE

This project was conceived as a part of the Special Five-Year Program on Sustainable Fisheries for Food Security in the ASEAN Region. It is to be implemented during 2006-2010. The project focuses on the following:

- 1) conduct of a holistic training program on sustainable aquaculture for technical persons from the region. Topics range from broodstock management and seed production to environment-friendly aquaculture, including feeds and feeding management as well as disease management
- 2) development of training programs for fish farmers that will put emphasis on practical sessions to include farm visits to countries with developed technologies
- 3) intensification of production and dissemination of manuals and handbooks on various aquaculture technologies and
- 4) promotion of the development of good farm practices for the various priority species.

In 2006, two training courses were held:

- 1) An international training on seed production and culture of abalone was held in November 2006 at the Tigbauan Station of SEAFDEC/AQD in the Philippines.
- 2) The international training course on "Marine Fish Hatchery Operations" was conducted on 03 May to 16 June 2006 at SEAFDEC/AQD. Four participants from Vietnam, Philippines, Indonesia and Cambodia were funded through the Program on the Promotion of Sustainable Aquaculture in the ASEAN Region. Three other technicians from Vietnam joined the practical part of the session and completed the special training program conducted during 29 May to 29 June 2006. Their participation was funded partly by the Program.

Meanwhile, the SEAFDEC/AQD's "Manual on Tilapia Farming in Ponds and Cages" was translated to Bahasa Melayu (Indonesia) and the Burmese language (Myanmar). Also, the Vietnamese "Manual on Mud Crab Culture" developed by the Government of Vietnam is being translated into English.

Proposed Activities for 2007

The following activities shall be conducted:

- 1) Publication of a manual on "Grow-out of *M. rosenbergii* in Ponds and Lake-based Cages"
- 2) Training course on marine fish hatchery. This aims to provide participants with technical knowledge and skills on the spawning and larval rearing of marine fishes, such as milkfish, grouper, snapper, sea bass and rabbitfish and enable them to operate a fish hatchery or a multi-species hatchery
- 3) Training course on abalone hatchery. The objective is to provide participants with technical knowledge and skills on seed production and grow-out culture of abalone to enable them to operate hatchery, nursery or grow-out farms of abalone.

The projects on "Development of Technologies for Sustainable Aquaculture" and "Human Capacity Building for Sustainable Aquaculture" will be continued in 2007. However, these projects will be merged and ac-



Participants learn hatchery techniques in the marine fish hatchery operations training course offered by the program.

tivities will be implemented under a new project entitled 'Development of Technologies and Human Capacity Building for Sustainable Aquaculture'.

The activity components under this project will remain the same as in 2006; however, research for next year will provide more focus on addressing gaps in areas of present needs (e.g. development of captive broodstock and improved quality seeds for the priority species, and improvement of husbandry protocols in the hatchery).

Activities that enhance the capacity of countries in the region on seed production and grow-out culture techniques of commercially important species (e.g. abalone, marine fishes) will also be continued.

Development of Fish Disease Surveillance System

This program is an offshoot of an earlier project entitled "Development of Fish Disease Inspection Methodologies for Artificially-Bred Seeds." This was conducted by SEAFDEC/AQD in 2000 to 2004 with funds from the Government of Japan.

The previous project focused on development of diagnostic methods for important viral diseases of aquatic animals in the region.

Researches on the development of standardized diagnostic methods, husbandry methods for disease control and a monitoring method for residual chemicals in aquaculture products were conducted and the outputs were disseminated to ASEAN countries.

The logical step after that was to establish the network of resources and facilities for fish health diagnosis and human capacity building in the region.

Thus, the project paved the way for the development

of the disease control and surveillance system for the region. The current program is called "Development of Fish Disease Surveillance System" to be implemented for five years from 2004 to 2008.

This program consists of 4 components:

- 1) research and development on refinement of diagnostic methods and development of new prevention methods for aquatic animal diseases
- 2) surveillance of important viral diseases of fish and shrimp in the region, and mobile clinics
- 3) distance-learning course (e-learning) and hands-on training on "Principles of Health Management in Aquaculture" and
- 4) Annual progress and planning meeting and international workshop on fish disease surveillance in the region.

Refinement of diagnostic methods and development of new prevention methods for aquatic animal diseases

This program component aims to refine established diagnostic methods for viral diseases of aquatic animals, and to develop new control prevention methods for fish diseases in the region.

Refinement of diagnostic methods. Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV), Yellow Head Virus (YHV), Gill Associated Virus (GAV) and Taura Syndrome Virus (TSV) infections were examined in 7 sampling sites in the Philippines (Capiz, Negros Occidental, Bohol, Quezon, Palawan, Misamis Occidental and Surigao del Sur provinces) during the dry and wet seasons.

Analyses of the samples taken during the dry season showed that GAV had the highest total prevalence of 25.5%. Total percent prevalence for IHHNV infection was 17.4%. YHV infection had a total prevalence of 1.4%. TSV was absent in all sites examined.

In the samples taken during the wet season, initial results of viral detection showed that the total prevalence for IHHNV infection was 11%. Prevalence of GAV infection was 10% for Negros Occidental, Bohol and Quezon, 15% for Palawan, 40% for Misamis Occidental and 50% for Capiz. There was no YHV prevalence in Capiz, Negros Occidental, Bohol, Quezon, Palawan and Misamis Occidental. TSV was not found in Capiz, Bohol, Quezon and Palawan.

Surveys for pathogens of giant freshwater prawn viral diseases, *Macrobrachium rosenbergii* nodavirus (MrNV) and extra small virus (XSV) were conducted in Central Thailand during June-October 2006.

The prawn larvae were sampled and analyzed for both viruses using reverse transcriptase polymerase chain reaction (RT-PCR). Twenty-three specimens out of the total of 92 specimens or 25% were recorded as RT-PCR positive for MrNV while 2 specimens (2.2%) were positive for XSV. Only 7 specimens or 7.6% were found positive for both MrNV and XSV.

The difference in gross clinical signs between pathogen-positive and pathogen-negative prawns was not obvious.

Green mussels (*Perna viridis*) were sampled from four coastal provinces in Thailand to determine the presence of parasitic fauna. Unidentified turbellarians were occasionally found on gills of the samples from the Gulf of Thailand and Andaman Sea. Intensity of turbellaria was very low.

The protozoan gregarine was also seen in gill filament and connective tissues but there was no obvious tissue damage in tissue sections. No *Marteilia* infection (Office International des Epizooties or OIE-notifiable diseases) was observed in all samples even though it has been reported in oysters in the previous study.

Tilapias were sampled from 16 farms in Thailand and investigated for abnormality and disease incidence. There were several species of internal and external parasites that affect tilapias. While they did not severely damage the fish, they however enhanced stress and induced the secondary infection caused by other pathogens.

There were also several bacteria isolated from diseased fish sample. *Streptococcus agalactiae* appeared to be the most virulent pathogen that caused high mortality in tilapia farms. Also observed were *Vibrio cholerae* and *Plesiomonas shigelloides*.

In the development of new prevention methods for fish and shrimp diseases, screening of different broodstocks for the presence of VNN using PCR was conducted last year. The result revealed that after nested PCR, 25-56% of the broodstocks (sea bass, mangrove red snapper, *E. coioides* grouper and *E. phosocoguttatus* grouper) were VNN-positive.

VNN-positive broodstocks were separated from VNN-negative and their eggs and larvae were screened and monitored for possible transmission of the virus.

Eggs from VNN-positive grouper broodstocks turned out to be positive also for VNN and showed a very low survival rate (1.0-7.5%) after 19-46 days.

Continued screening of the milkfish and snapper broodstocks were done last March. The result revealed that of the 54 milkfish broodstocks kept in two 150-t tanks, 23 or 43% were VNN positive. For the snappers in the 20-t tank, 6 out of the 8 broodstocks or 83% had VNN.

Monthly sampling of different species of wild finfish caught in Panay Gulf in the Philippines was conducted for 12 months starting September 2005 until August 2006 to determine the prevalence of VNN. A total of 18 species of marine finfish were collected for the whole year. Results revealed that all species were positive for VNN but at a relatively lower prevalence compared to the trash fish samples collected from Iloilo Fish Port and screened last year.

Tiger shrimps given immuno-stimulants had better immune responses and survival after WSSV challenge than those without immuno-stimulants. Shrimps were injected with the formalin-killed WSSV vaccine. There-

after, the shrimps were experimentally infected with WSSV. The results are being analyzed.

Surveillance on important viral diseases of fish and shrimps in the region. This component aims to establish a network of surveillance system with national laboratories in the region.

This network will be a resource and/or reference laboratory for diagnosis of fish and shrimp viral diseases. Surveillance activities will be coordinated with “mobile clinics,” in which SEAFDEC/AQD Surveillance Teams will make on-site diagnoses and assist in setting up a fish disease diagnostic capability/facility in SEAFDEC member countries.

SEAFDEC/AQD has formed surveillance teams for shrimp and fish. These teams are responsible for visiting areas for disease surveillance.

Trips for active surveillance were conducted in several areas in the Philippines. Crustacean stocks at SEAFDEC/AQD are being monitored and passive data from its Diagnostic Service laboratory are being collated.

Species included in the monitoring are mud crabs, *Penaeus monodon*, *P. indicus*, *P. merguensis*, *P. vannamei* and the freshwater prawn *Macrobrachium rosenbergii*. Among the *P. vannamei* stocks from the BFAR-accredited farms, several instances of white spot infection have been documented. Higher prevalence was consistently observed in native species of shrimp compared with *P. vannamei*.

During a trip to Cambodia, the country’s lack of capability in fish health in both staff and laboratory facilities was highlighted. In view of this, an on-site training in the project was proposed for Cambodia and Myanmar. Meanwhile, a flyer that outlines techniques for fixation of shrimp and other crustacean samples, as well as methods for sending them to a diagnostic laboratory was printed.

The SEAFDEC/AQD Fish Team collected tissue samples of *koi*, common grass and silver carp from Cambodia, Myanmar, Philippines and Southern Vietnam in January to February 2006. The fish samples were found free of systemic bacterial infection and no significant parasitic infestations of the gills were observed.

These specimens were processed and assayed for KHV, GCHDV and SVCV by cell culture, by pathogenicity test on native common carp and by PCR.

Results showed that the tissue filtrates of all fish samples did not cause cytopathic effects on inoculated cell cultures. The pathogenicity tests did not also indicate the presence of pathogenic virus. One step and nested



The tilapia farm sampling sites in Thailand: earthen pond (left); hapa net cage setting in earthen pond (below) and cage culture setting in canal (bottom).

PCR tests for SVCV and GCHDV of all fish samples showed negative results. The same PCR tests for KHV yielded negative results for fish samples from Myanmar but results for the other countries were inconsistent and are currently being verified.

Mobile clinic services were conducted for epizootics of tilapia (*Oreochromis niloticus*), *Anabas* sp. and rohu in four farms in Myanmar in January 2006.

Results indicated the presence of bacterial infection among tilapia with no significant parasitic infestation. Viral assays by cell culture did not detect the presence of virus in E-11 cells. Tilapia cells for virus isolation are not available.

E-learning on “Principles of Health Management in Aquaculture.” SEAFDEC/AQD opened a 5-month distance-learning course (e-learning) on “Principles of Health Management in Aquaculture” last September 4, 2006 with 16 participants; 10, with fellowship and 6, private.

Participants learn knowledge and skills in fish health management through a CD-ROM and internet-based discussion boards. The course aims at increasing the diagnostic capability of SEAFDEC member countries, and at supporting the establishment of a surveillance network.

Annual progress and planning meeting. The Annual Progress and Planning Meeting was conducted by SEAFDEC/AQD in Tigbauan, Iloilo, Philippines on 02 March 2006.

The Meeting was attended by 15 participants comprising the study leaders from Thailand (AHHRI), Indo-

nesia (FHRL) and the Philippines (SEAFDEC/AQD) as well as representatives from the National Research Institute of Aquaculture (NRIA), Japan, SEAFDEC Secretariat and SEAFDEC/AQD.

This activity reviewed the progress of research studies for each year under the project and discussed research plans and project schemes for the next year.

Proposed Activities for 2007

Development of new prevention methods for aquatic animal diseases

Development of control methods for viral nervous necrosis (VNN) of marine fish. To establish a management strategy that maintains virus-free stocks of the economically important fishes, a disinfection method for VNN-positive eggs using ozone and other possible disinfectants will be established. Also, vaccination to enhance fish immune system will be carried out using DNA vaccine.

Development of immunological preventive methods for shrimp. The study aims to develop immunoprophylactic methods of WSSV prevention in shrimp.

Epidemiology of the white spot syndrome virus in different shrimp culture techniques in the Philippines. This study will identify pond-level risk factors and develop white spot shrimp virus (WSSV) prevention and management strategies through an epidemiological approach.

A longitudinal study will be conducted from stocking to harvest to identify the risk factors associated with

Study leaders and project implementors of the SEAFDEC-ASEAN FCG regional program on disease surveillance system for aquatic animals attend their Annual Progress and Planning Meeting at SEAFDEC/AQD in Tigbauan, Iloilo, Philippines. The meeting reviewed the program's past year progress and planned its activities for the following year.



WSSV in shrimp ponds and natural mangrove habitat in the Philippines.

Pilot testing of the “indigenous probiotic” in grow-out shrimp ponds. This study aims to test the efficiency of the “indigenous probiotic” in preventing the outbreak of luminous Vibriosis in grow-out ponds. The “indigenous probiotic” will be mass produced.

Survey of viral diseases of Pacific white shrimp in Indonesia. A survey of TSV and other shrimp viral pathogens in Pacific white shrimp (*P. vannamei*) will be conducted in Indonesia.

Hemorrhage disease on cultured freshwater catfish in Mekong Delta. Freshwater catfish (*Pangasianodon hypophthalmus*) is the main product in the Mekong Delta. Haemorrhage disease causes mass mortality in cultured freshwater catfish in this area.

There are only few reports on the hemorrhage disease of the freshwater catfish in Mekong Delta. Thus, this study aims to identify the pathogen agents causing hemorrhage disease in cultured freshwater catfish.

Research and analysis of chemical residue in aquaculture. This study will be conducted to determine the levels of chemical contaminants such as pesticide and antibiotics in marine aquaculture fish and fish products in Southeast Asia. It will also determine the withdrawal period of different antibiotics currently used in cultured marine fish and shrimp.

Surveillance of important viral diseases of fish and shrimps in the region

Monitoring and surveillance of transboundary pathogens in cultured shrimps and freshwater prawn. The disease status of cultured shrimps and prawn in selected Southeast Asian countries, specifically diseases notifiable to the OIE like WSSV, TSV and significant emerging diseases will be studied.

The study will also appraise the extent of infection to support management decisions regarding movement of shrimps and prawns for aquaculture. Information gathered in this surveillance activity will be disseminated through the various training and dissemination activities of the Program.

Surveys of giant freshwater prawn viral diseases in Thailand. This study aims to provide information for better understanding of the spread of the viruses and the disease conditions of the prawns infected by the two viruses.

Surveillance of emerging fish viral pathogens in some Southeast Asian countries. The presence of KHV, GCHDV and SVCV will be monitored through *in situ*

samplings of affected fish during outbreaks and of carrier fish. Fish samples will be collected in the Philippines, Lao PDR, Myanmar and Cambodia with the assistance of former trainees or with collaborating scientists.

Detection of viral pathogens will likewise be conducted through pathogenicity/cohabitation experiments. Viral presence in collected samples will be further confirmed using PCR, RT-PCR or other sensitive molecular tests. In addition, enhancement of technical expertise through hands-on training of cooperating staff and on-site demonstration of virological techniques will be made during sampling visits. In addition, on-site training will be offered for fish health workers in Myanmar.

In addition, strengthening of virus laboratory facilities through provision of cell cultures and standard protocols will be pursued. Emergency mobile clinics will be initiated during outbreaks of fish disease to assist fish health workers in SEAFDEC member countries.

Hands-on training. A training course on advanced diagnostic techniques for important diseases of fish and crustaceans will be conducted. It consists of DNA-based diagnostic methods and other important diagnostic techniques for shrimp and fish diseases.

At the end of the training course, the participants from SEAFDEC member countries are expected to have sufficient skills to act as national trainers or core persons in the diagnosis of viral diseases in their respective countries.

Annual progress and planning meeting. The Annual Progress and Planning Meeting will be held to review the progress of research studies for 2007 and to discuss research plans and project scheme for 2008. All study leaders from the Philippines, Thailand, Indonesia, and Vietnam will attend this annual meeting. An external evaluator from Japan will also be invited to the meeting.

International workshop. An international workshop will be held in 2007 to:

- 1) review the present status and problems on aquatic animal diseases in SEAFDEC member countries
- 2) discuss output of the project with the member countries, and
- 3) discuss an efficient collaboration in developing surveillance systems for aquatic animal diseases in Southeast Asia with the member countries and other organizations such as OIE and FAO (Food and Agriculture Organization of the United Nations)

Publication. A text book on aquatic animal health will be published in 2007.

Stock enhancement for threatened species of international concern

This program started in 2005 with a workshop that determined threatened species and assessed the existing hatchery and stock enhancement technologies for the identified species. This is a five-year program that ends in 2009.

The objectives of the Program are to:

- 1) review past and present stock enhancement programs to conserve threatened species in Southeast Asia
- 2) develop ecologically sound strategies for stock enhancement including hatchery production and release of genetically diverse and disease-free juveniles
- 3) encourage participation of local communities in stock enhancement
- 4) develop methods and criteria for monitoring and evaluation of stock enhancement and conservation success and
- 5) transfer the stock enhancement technologies and social strategies to the countries in the region.

The Program includes the following activities:

- 1) Regional Workshop to review the status of stock enhancement in Southeast Asia, identify threatened species, and assess the existing technologies for such species
- 2) research on strategies for sea ranching and stock enhancement
- 3) verification of developed and established technologies
- 4) training and information dissemination on stock enhancement.

Strategies of sea ranching and stock enhancement

Seed production of identified species. Several species of seahorse broodstocks were obtained from Visayas and Palawan areas in the Philippines. These wild broodstocks spawned in the SEAFDEC/AQD hatchery.

Plans for seed production of sea cucumber have been discussed between the Research Institute of Aquaculture No.3 (RIA3) of Vietnam and SEAFDEC/AQD.

Development of release strategies for suitable species. Juvenile abalones were released in Sagay Marine Reserve (SMR) located in the northern part of Negros Occidental in the Philippines in July 2006 to find out the better method for higher survival of abalones after release.

Behavioral studies of abalone on the avoidance of predators were conducted to assess the effectiveness of conditioning of abalones. Also, the impact of color tagging, developed by SEAFDEC/AQD, on the survival of abalone was studied. More experiments are required to obtain conclusive results.

The first batch of true giant clam, *Tridacna gigas*, was stocked in cages in Carbin Reef, in the Philippines' Sagay Marine Reserve in March 2006. This was followed by the stocking in August 2006 in Kawit Reef, Malalison Island, Philippines. The survival and growth of clams were monitored monthly to evaluate the methods.

Assessment of potential sites for stock enhancement. Local fisher folks collecting abalone and buyers of abalone were interviewed in Sagay Marine Reserve (SMR) in the Philippines to determine the status of abalone fisheries in the region.

The SMR was chosen as the release site for abalone and giant clam, and Malalison island in Antique, Philippines was chosen as stocking site for giant clam. The criteria used were environmental factors and ecosystems of the site (wild population of the target species, availability of food, abundance of predators, etc.), conservation/protection of the site and ease of access.

Stocking sites suitable for seahorses and sea cucumber are still under consideration.

Training and information dissemination. The training course on stock enhancement of threatened species planned in 2006 was canceled due to insufficient budget.

The Proceedings of the Regional Technical Consultation was published in September 2006 while a manual for stock enhancement of giant clam is now under preparation and will be published by the second quarter of 2007.

Publication of two manuals, "Breeding technology for two species of catfish (*Clarias macrocephalus* and *Pangasianodon gigas*)", and "Breeding technology for Asian Arowana (*Scleropages formosus*)" did not push through due to insufficient budget.

Proposed Activities for 2007

Strategies of sea ranching and stock enhancement

Seahorse. In order to obtain sufficient amount of good quality seeds for stock enhancement, existing

breeding techniques developed by SEAFDEC/AQD will be improved. Management and feeding scheme for all stages will be refined to reduce cost of natural food organisms and explore possible replacement using artificial diets.

Stocking sites suitable for seahorses will be assessed. To monitor the released stock, tagging techniques will be developed by incorporating chemicals into the diet as in mollusks or using coded tags inserted into the skin or abdominal cavity of seahorses. Monitoring will be done every two months.

Humphead wrasse. The humphead or Napoleon wrasse, *Cheilinus undulatus*, is one of the largest and the most valuable reef fish, and considered threatened and listed in Appendix II of CITES in 2004.

The breeding and artificial seed production technology of this species has not yet been established. SEAFDEC/AQD will start studies on seed production of humphead wrasse in 2007.

Abalone. The following activities are proposed:

- 1) survey in SMR of wild stock of abalone and availability of seaweed species
- 2) development of appropriate release strategies (i.e. suitable size, stocking density or season) for stock enhancement and sea ranching of abalone
- 3) monitoring of growth performance and survival of abalone after release in their natural environment
- 4) development of proper harvest or recapture techniques (i.e. size, quantity or management techniques) that will sustain the enhanced fishery and
- 5) study on the methodology for pre-release conditioning of abalone

Giant clam. The following studies will be conducted further:

- 1) monitoring of temperature, salinity, turbidity, nutrients in the three sites stocked with *T. gigas*
- 2) comparison of the three habitats based on water parameters obtained and
- 3) correlation of water parameters with growth and survival of *T. gigas*

Sea cucumber. Studies on development of seed production method aimed for stock enhancement will be implemented in Vietnam (RIA3) and SEAFDEC/AQD.

Angelwing clam. The angelwing clam *Pholas orientalis*, a deep burrowing bivalve commonly found in the tidal flats of Southeast Asia, is one of the most expensive and sought after bivalve in the Philippines.

This high demand led to indiscriminate harvesting resulting in the depletion of natural stocks. To produce

and complete the life cycle of angelwing clams in captivity and to rehabilitate depleted stocks through release of hatchery-produced juveniles, the following studies will be implemented in 2007:

- 1) survey of sites for possible sources of *P. orientalis* broodstock and also possible sites for release
- 2) development of technology for seed production of *P. orientalis* in the hatchery
- 3) identification of appropriate size-at-release of *P. orientalis* for stock enhancement purposes.

Socio-economic study. The success of stock enhancement activities depends on its cost-effectiveness and the efficiency of allocation of economic and social gains to intended beneficiaries and stakeholders.

To establish accountability and facilitate formulation of fisheries management policies, including identification of access rights among stakeholders, information cost-effectiveness and overall economic and social gains are essential.

This study shall determine the costs of and benefits from stock enhancement activities being conducted in Negros Occidental in the Philippines. It shall also assess the efficiency of allocation of economic and social gains to intended beneficiaries and stakeholders. To achieve this goal, the following studies are planned:

- 1) characterization of the cost structure of stock enhancement initiatives at various scales and modes as applied by SEAFDEC/AQD and collaborators
- 2) determination of the typologies of benefits from stock enhancement
- 3) assessment of stakeholders directly and immediately benefiting from stock enhancement initiative of SEAFDEC/AQD and collaborators
- 4) evaluation of the nature of participation of coastal communities in stock enhancement and determination of measures to compensate for such types of investments
- 5) identification of policy implications, especially on access rights, to stock-enhanced fisheries that are acceptable to most stakeholders and
- 6) identification of socio-economic indicators and strategies for promoting responsible practices for managing enhanced stocks

Training and information dissemination. Activities such as organization of training courses or information dissemination (i.e. publication of manuals) will not be implemented under this program. However, some of the activities related to the objectives of this program (e.g. training course on abalone hatchery) will be implemented under another Trust Fund Program, "Promotion of Sustainable Aquaculture in the ASEAN Region".

Training and Information Dissemination Programs

S EAFDEC/AQD disseminates and applies its research findings mainly through its training and information programs.

Its training program offers regular and special training courses for fish farmers, extension workers, researchers and academicians, and students. Trainees usually come mainly from government institutions. Private sector representatives like fish farmers, technicians and other workers also participate in the training courses.

Training methods include both classroom-type activities, workshops, and laboratory and field work.

In addition to these activities, SEAFDEC/AQD also provides opportunities for students to undergo internship and on-the-job training programs.

The information program consists of regular publications, mass media news service, participation in fairs and exhibits, a FishWorld museum, and library services.

Training Program

S EAFDEC/AQD trained some 200 government officers and private sector practitioners in 15 courses. Participants' ages ranged from 18 to 65 years old, and 22% of them were female.

The training courses are of four types: distance or e-learning experiences, international courses with funding support from the Government of Japan (GOJ) in the form of fellowships for SEAFDEC member countries, special courses tailored to the needs of requesting participants, and internships, on-the-job training, and practicum.

International training

Marine Fish Hatchery. This regular training course was conducted on 03 May to 16 June 2006. Eight (8) participants, mostly government officers from Australia, Cambodia, Indonesia, Vietnam and the Philippines, attended the course.

Abalone Hatchery Seed Production and Culture. Twelve (12) government officers and representatives of the private sector participated in this training course conducted on 09-30 November 2006. The participants came from Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand, and Vietnam.

Responsible Aquaculture Development. The training/workshop was conducted 17-20 January 2006 for 24 government officers of the Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) and Local Govern-

ment Units in the Mindanao-Sulu-Palawan area. This activity is part of SEAFDEC/AQD's commitment to the ASEAN Human Resources Development Project on Sustainable Fisheries in the Brunei Darussalam-Indonesia-Malaysia-Philippines East Asian Growth Area (BIMP-EAGA).

Shrimp Health Management. This 4-day training was conducted on 22-23 May 2006 in Bandar Seri, Brunei Darussalam for 22 government officers. This training was also part of the BIMP-EAGA/ASEAN program.

Farm-based Feed Preparation for Freshwater Aquaculture. On 12-15 September 2006, SEAFDEC/AQD conducted a training course on preparation of farm-based feed for freshwater aquaculture. This was another BIMP-EAGA training activity in West Kalimantan, Indonesia organized for 10 technicians and fish farmers.

On-line distance learning

SEAFDEC/AQD conducts an ongoing Internet-based distance learning course on "Principles of Health Management in Aquaculture." This is a 5-month course that started 04 September 2006.

There are currently 16 participants from government institutions, research and academic and private sector organizations representing 12 countries - Brunei Darussalam, Cambodia, England, Indonesia, Malaysia, Mexico, Myanmar, Panama, Philippines, Singapore, Thailand and Vietnam.

Special training courses

Milkfish Production. Three technical staff of the Ministry of Fisheries' Research Institute for Aquaculture of the Government of Vietnam came to SEAFDEC/AQD for a special training program on milkfish production. The course was held from 29 May to 29 June 2006.

Freshwater Fish Feed Preparation. This was an on-site, hands-on training on tilapia feed formulation held on 05-07 July 2006 for fish farmers of Isabela Province of the Philippines. The Department of Science and Technology (DOST), together with the Local Government Unit of the Province of Isabela, requested resource persons from SEAFDEC/AQD Binangonan Freshwater Station (BFS) to train the local fish farmers.

Freshwater Aquaculture. Two officers from LGUs and three private sector representatives trained on freshwater aquaculture in four separate 10-day sessions held on 27 March-7 April, 15 May- 05 June, 25-27 September and 6-17 November.

Freshwater Prawn Hatchery and Grow-out Operations. This training course was held on 17-22 April 2006. Twenty one government officers, farmers, and representatives of academic institutions and peoples' organizations recommended by various local government units from five municipalities in the Philippines participated in the course.

Abalone Hatchery Seed Production and Culture. This two-week special training course was held on 15-29 August 2006. Sixteen participants representing the

Philippines' Zamboanga provincial government, the academe, and the private sector completed the course.

Sea bass and Seaweeds Culture. Eighteen members of the Mag-aba Multipurpose Coop (MMPC) of the Philippines' provincial government of Antique, an agriculture technician and a municipal agriculture officer were trained on site last 20-22 September 2006.

Sea bass Culture in Cages and Ponds. On 02-04 August 2006, ten fishpond caretakers and pond laborers trained on sea bass culture. This course was also sponsored by the provincial government of Antique.

Mud crab Culture. Twenty six faculty members, students and laborers of the Philippines' Polytechnic State College of Antique attended a mud crab culture training on 21-24 November 2006.

On-the-job training and internships

On-the-job training and internships are a regular service provided by SEAFDEC/AQD to assist local fishery schools and other academic institutions in the Philippines in training their students on aquaculture operations. The students are assigned different tasks in hatchery, nursery, grow-out, natural food, feed formulation and other relevant operations. Designated SEAFDEC/AQD staff serve as supervisors and assess the students' performance.

In 2006, this service catered to 211 students from Iloilo and Panay island and from various provinces in the Visayas and Mindanao regions. Some 34 institutions participated in this service.



The SEAFDEC/AQD training program collaborates with the ASEAN Human Resources Development Project on Sustainable Fisheries in the Brunei Darussalam-Indonesia-Malaysia-Philippines East Asia Growth Area (BIMP-EAGA). At left are the participants in the training course on preparation of farm-based feed for freshwater aquaculture held in West Kalimantan, Indonesia. Right photo shows a participant receiving his certificate of attendance after completing the training on shrimp health management. The training was conducted in Bandar Seri, Brunei Darussalam.

Information Dissemination Program

In addition to its training program, SEAFDEC/AQD utilizes various methods to ensure that its research information are disseminated to its aquaculture industry stakeholders. These include the following:

- 1) publishing research results in scientific journals and other similar publications
- 2) publication of manuals, flyers, annual reports, reports of scientific meetings, etc.
- 3) participation in aquaculture and related fairs and exhibits
- 4) maintaining a responsive, up-to-date library service
- 5) servicing mass media with aquaculture information
- 6) conduct of in-house seminars
- 7) maintaining an active and regularly updated website
- 8) SEAFDEC/AQD FishWorld.

Publishing research results in scientific journals and similar publications

SEAFDEC/AQD had 32 research papers published in the past year. Sixteen of these appeared in journals and the rest were published in proceedings of seminars, workshops and other scientific meetings.

The following are the research papers published in scientific journals:

- 1) Ayson FG, Takemura A. 2006. Daily expression patterns for mRNAs of Gh, TRL, SL, IGF-I and IGF-II in juvenile rabbitfish, *Siganus guttatus*, during 24-h light and dark cycles. *General and Comparative Endocrinology* 149:261-268.
- 2) Azad IS, Jithendran KP, Shekhar MS, Thirunavukarasu AR, de la Peña LD. 2006. Immunolocalisation of nervous necrosis virus indicates vertical transmission in hatchery produced Asian sea bass (*Lates calcarifer* Bloch) - A case study. *Aquaculture* 255:39-47.
- 3) Coniza EB, Tan-Fermin JD, Catacutan MR, Triño AT, Agbayani RF. 2000. Economic evaluation of grow-out diets for Asian catfish *Clarias macrocephalus* (Gunther) production. *University of the Philippines in the Visayas Journal of Natural Sciences* 5:43-54.

- 4) Cortado HH, San Luis BB, de la Peña L, Monsalud RG, Hedreya CT. 2005. Local *Vibrio* isolates exhibit molecular characteristics distinct from reference *V. harveyi* and *V. campbellii* strains. *Science Diliman* 14:23-30.
- 5) Gonzales TT, Katoh M, Ishimatsu A. 2006. Air breathing of aquatic burrow-dwelling eel goby, *Odontamblyopus lacepedii* (Gobiidae: Amblyopinae). *Journal of Experimental Biology* 209:1085-1092.
- 6) Luhan MRJ, Harder F, Hurtado AQ. 2006. Growth and agar quality of *Gracilaria heteroclada* (Zhang *et* Xia) grown in a filter tank. *The Philippine Agricultural Scientist*. 89: 4, 359-362.
- 7) Nagasawa K. 2004. Sea lice, *Lepeophtheirus salmonis* and *Caligus orientalis* (Copepoda: Caligidae), of wild and farmed fish in sea and brackish waters of Japan and adjacent regions: A review. *Zoological Studies* 43:173-178.76)
- 8) Nagasawa K. 2005. Proposed activities for *koi* herpes virus disease at the SEAFDEC Aquaculture Department. *Bulletin of the Fisheries Research Agency (Supplement No. 2):* 79-86.
- 9) Ohtsuka S, Ho JS, Nagasawa K, Moron-zinska-Gogol J, Piasecki W. 2004. The identity of *Limnorea diuncata* Kokubo, 1914 (Copepoda, Poecilostomatoida) from Hok-kaido, Japan, with relegation of *Diergasilus* Do, 1981 to a junior synonym of *Thersitina* Norman, 1905. *Systematic Parasitology* 57:35-44.
- 10) Pedroso FL, de Jesus-Ayson EGT, Cortado HH, Hyodo S, Ayson FG. 2006. Changes in mRNA expression of grouper (*Epinephelus coioides*) growth hormone and insulin-like growth factor I in response to nutritional status. *General and Comparative Endocrinology* 145:237-246.
- 11) Primavera JH. 2005. Mangroves, fishponds, and the quest for sustainability. *Science* 310:57-59.
- 12) Primavera JH. 2006. Overcoming the impacts of aquaculture on coastal zone. *Ocean and Coastal Management* 49:531-545.

- 13) Salayo ND. 2006. Price relationships in Philippine milkfish markets: Univariate and causality analysis. *Aquaculture Economics and Management* 10:59-80.
 - 14) Tendencia EA, de la Peña MR, Choresca CH Jr. 2006. Effect of shrimp biomass and feeding on the anti-*Vibrio harveyi* activity of Tilapia sp. in a simulated shrimp-tilapia polyculture system. *Aquaculture* 253:154-162.
 - 15) Tendencia EA, de la Peña MR, Choresca CH Jr. 2006. Presence of snapper, sea bass, and siganid inhibits growth of luminous bacteria in simulated shrimp culture system. *Aquaculture* 260:54-60.
 - 16) Tendencia EA, Fermin AC, de la Peña MR, Choresca CH Jr. 2006. Effect of *Epinephelus coioides*, *Chanos chanos*, and GIFT tilapia in polyculture with *Penaeus monodon* on the growth of the luminous bacteria. *Aquaculture* 253:48-56.
 - 17) Toledo JD, Naret E, Nakagawa H. 2005. Comparison of fatty acid profile between cultured and wild-caught grouper, *Epinephelus coioides*. *Aquaculture Science* 53:127-134.
 - 18) Walton ME, Le Vay L, Leбата JH, Binas J, Primavera JH. 2006. Seasonal abundance, distribution and recruitment of mud crabs (*Scylla* spp.) in replanted mangroves. *Estuarine Coastal Shelf Science* 66:493-500.
- Research papers published in proceedings of scientific meetings are the following:
- 1) Chavez DR, Ogata HY, Garibay ES, Sollesta HT, Tibubos KR. 2006. Arachidonic acid enrichment of rotifers and effects of dietary arachidonic acid on broodstock performance of rabbitfish *Siganus guttatus*. In: Nakamura K (ed.). *Sustainable Production Systems of Aquatic Animals in Brackish Mangrove Areas*. Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan: JIRCAS Working Report No. 44; pp. 49-52.
 - 2) Cuvin-Aralar ML. 2005. Microcystins from the cyanobacteria *Microcystis aeruginosa* in Laguna de Bay, Philippines. In: Cuvin-Aralar ML, Punongbayan RS, Santos-Borja A, Castillo LV, Manalili EV, Mendoza MM (eds.). *Proceedings of the First National Congress on Philippine Lakes (LakeCon2003)*. Los Baños, Laguna, Philippines: SEAMEO, SEARCA; pp. 116-122.
 - 3) Eguia RV, delos Reyes A, Jr. 2005. Hi-density tank culture of Nile tilapia (*Oreochromis niloticus*) using lake water with effluent management. In: Cuvin-Aralar ML, Punongbayan RS, Santos-Borja A, Castillo LV, Manalili EV, Mendoza MM (eds.). *Proceedings of the First National Congress on Philippine Lakes (LakeCon2003)*. Los Baños, Laguna, Philippines: SEAMEO, SEARCA; pp. 205-213.
 - 4) Kiryu I, de la Peña LD, Maeno Y. 2006. Detection of betanodavirus from different organs of broodstocks and wild juveniles of orange-spotted grouper, *Epinephelus coioides*. In: Nakamura K (ed.). *Sustainable Production Systems of Aquatic Animals in Brackish Mangrove Areas*. Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan: JIRCAS Working Report No. 44; pp. 53-55.
 - 5) Ogata HY, Ahmed K, Garibay ES, Chavez DR, Furuita H, Chong VC. 2006. Arachidonic acid distribution in mangrove organisms in the Philippines, Malaysia and Japan. In: Nakamura K (ed.). *Sustainable Production Systems of Aquatic Animals in Brackish Mangrove Areas*. Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan: JIRCAS Working Report No. 44; pp. 45-48.
 - 6) Okuzawa K, Leбата J, Buen-Ursua SMA, Quintio ET. 2006. The SEAFDEC/AQD Experience in Stock Enhancement. In: Primavera JH, Quintio ET, Eguia MRR (eds.). *Proceedings of the Regional Technical Consultation on Stock Enhancement for Threatened Species of International Concern*; 13-15 July 2005; Iloilo City, Philippines. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department; pp. 17-26.
 - 7) Platon RR. 2003. Mangrove-friendly shrimp culture technique: Thailand Research Plan. In: Eleftheriou M, Eleftheriou A (eds.). *Proceedings of the ASEM Workshop AQUA-CHALLENGE*, Beijing China, 23-30 April 2002. *Aquaculture Challenges in Asia after the Bangkok Declaration on Sustainable Aquaculture. The next step*; Luxemburg, OPOCE: ASEM Science and Technology Workshops (2); pp. 34-36.
 - 8) Primavera JH. 2003. Towards more environmentally responsible grow-out systems in aquaculture. In: Eleftheriou M, Eleftheriou A (eds.). *Proceedings*

- of the ASEM Workshop AQUACHALLENGE, Beijing China, 23-30 April 2002. Aquaculture Challenges in Asia after the Bangkok Declaration on Sustainable Aquaculture. The next step; Luxembourg, OPOCE: ASEM Science and Technology Workshops (2); pp. 22-25.
- 9) Romana-Eguia MRR. 2006. Application of DNA-based markers in stock enhancement programs. In: Primavera JH, Quinitio ET, Eguia MRR (eds.). Proceedings of the Regional Technical Consultation on Stock Enhancement for Threatened Species of International Concern; 13-15 July 2005; Iloilo City, Philippines. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department; pp. 7-16.
 - 10) Santiago C, Focken U, Gonzal AC, Laron MA. 2005. Aquaculture practices in Laguna de Bay, Philippines. In: Cuvin-Aralar ML, Punongbayan RS, Santos-Borja A, Castillo LV, Manalili EV, Mendoza MM (eds.). Proceedings of the First National Congress on Philippine Lakes (LakeCon2003). Los Baños, Laguna, Philippines: SEAMEO, SEARCA; pp. 193-204.
 - 11) Sim YS, Rimmer MA, Toledo JD, Sugama K, Rumengan I, Williams KC, Phillips MJ. 2005. A Guide to Small-Scale Marine Finfish Hatchery. NACA: Bangkok, Thailand; 17p.
 - 12) Sim YS, Rimmer MA, Williams KC, Toledo JD, Sugama K, Rumengan I, Phillips MJ. 2005. A Practical Guide to Feeds and Feed Management for Cultured Groupers. NACA: Bangkok, Thailand; 17p.
 - 13) Toledo JD, Golez MS, Ohno A. 2005. Studies on the use of copepods in the semi-intensive seed production of grouper *Epinephelus coioides*. In: Lee CS, O'Bryen P, Marcus N (eds.). Copepods in Aquaculture. Blackwell Publishing, Oxford, U.K.; pp. 169-182.
 - 14) Yap WG. 2002. A strategy for sustainable mariculture. In: Yusoff FM, Shariff M, Ibrahim HM, Tan SG, Tai SY (eds.). Tropical Marine Environment: Charting Strategies for the Millennium; Malacca Straits Research and Development Centre (MASDEC); Serdang, Malaysia: Universiti Putra Malaysia; pp. 189-210.

Publications

The following publications were published in 2006:



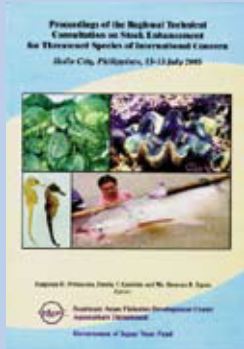
Responsible Aquaculture in Southeast Asia. This 47-page guidebook presents the 22 concepts, principles or policy statements that prescribe the preferred ways of doing and acting to ensure the sustainable use of mangroves for fish farming. It is annotated with definitions, explanations and many examples. Published jointly by ASEAN and SEAFDEC, this guidebook is a result of a Southeast Asian-wide consultation with core experts and country representatives in 2004 to 2005.



Code of Practice for Sustainable Use of Mangrove Ecosystems for Aquaculture in Southeast Asia. Edited by TU Bagarinao, this 43-page guidebook presents the code of conduct that has been re-written, expanded, clarified and annotated with definitions and examples to consider the fish farming industries in Southeast Asia. The source of the code is the Food and Agriculture Organization's technical guidelines (Articles 9.1 to 9.4) which were discussed in a regional consultation in 2001.

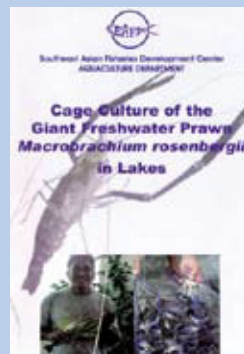


Report of the Third Roundtable Discussion on the Development of Genetically Improved Strain of *Macrobrachium*. A Collaborative Research under the Aquaculture Component of the ASEAN-SEAFDEC Special Five-Year Program on Sustainable Fisheries for Food Security in the ASEAN Region.



Proceedings of the Regional Technical Consultation on Stock Enhancement of Species Under International Concern. Edited by Primavera JH, Qumitio ET, Eguia MRR, this 149-page book has review papers and 7 country papers. The review papers discuss the ASEAN-SEAFDEC directives, DNA-based markers in stock enhancement, programs and efforts in enhancing stocks of giant

clams, corals, topshell, echinoderms, seahorse and giant catfish. The country papers include Japan, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand and Vietnam.

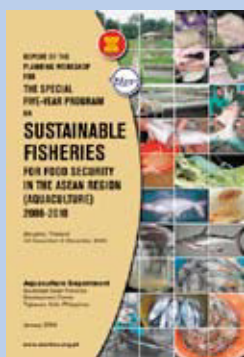


Cage Culture of the Giant Freshwater Prawn *Macrobrachium rosenbergii* in Lakes. Illustrates with color photographs the steps in growing freshwater prawn, from broodstock and larval rearing to nursery and grow-out.



Living with Suso in Bangus Ponds. A tip for fish farmers, the flyer summarizes the life history of “susò” or *Cerithidea cingulata* which are considered pests in milkfish ponds. It recommends steps to deal with the problem, such as complete sun-

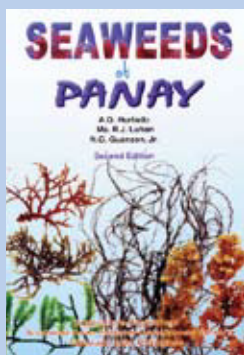
drying of ponds and installing gate screens, use of metaldehyde instead of the banned Brestan and triphenyltin, and turning “susò” into farm income.



Report of the Regional Planning Workshop for the Special Five-Year Program (Aquaculture Component): 2006-2010. A 59-paged report on the Regional Planning Workshop for the Special Five-Year Program on Sustainable Fisheries for Food Security in the ASEAN Region (Aquaculture) 2006-2010, held in Bangkok, Thailand, 30 November to 2 December, 2005.



Oil Spill. A flyer providing relevant information on the recent oil spill on the shores of some parts of Guimaras Island.



Seaweeds of Panay. Authored by SEAFDEC/AQD researchers AQ Hurtado *et al.*, this 50-page book lists 112 species of seaweeds found in Panay island in west central Philippines, 27 of which are new records to the area. Each color photograph is accompanied by a physical description. Common names, seaweed habitat, economic importance, and collection sites are also noted.



AQD Matters. This is the monthly in-house newsletter primarily intended for the SEAFDEC/AQD staff. It provides the latest news and information.



AQD Highlights 2005. SEAFDEC/AQD’s annual report for 2005. The report highlights the research results, training and information activities.

Participation in fairs and exhibits

SEAFDEC/AQD continued to participate in various fairs and exhibits as the Philippine aquaculture industry focused its interest on milkfish, genetics in aquaculture, the business side of aquaculture, abalone, shrimp, and tilapia.

To make its exhibits attractive to viewers, the usual features include a thematic visual design, posters, book-selling, publication displays, and consultations with staff. Live aquaria and computer presentations are also shown.

In 2006, SEAFDEC/AQD installed its exhibit booths at the following events:

First Western Visayas Milkfish Congress. This was held on 24-26 October in Iloilo City and was hosted by the Iloilo Fish Producers Association.

AGRILINK/FOODLINK/AQUALINK. This was a trade fair organized by a consortium of public and private companies and held on 05-07 October at the World Trade Center in Manila.

TECHNONEGOSYO EXPO. The Department of Science and Technology (DOST) organized this event which was held on 14-15 September in Manila. On this occasion, SEAFDEC/AQD presented its agree-build-operate-transfer concept for science-based, ready-for-handover operational businesses for new and re-focusing entrepreneurs.

First Regional Cluster Technology Forum and Product Exhibition. This was organized by the Depart-

ment of Agriculture–Region 6 on 05 September at Punta Villa, Iloilo City. The SEAFDEC/AQD exhibit featured its abalone farming and hatchery technologies.

ICEMAN 2006. This was the International Conference-Exhibition on Mangroves of Indian and Western-Pacific Oceans held in Kuala Lumpur, Malaysia, on 21-24 August.

Fifth National Prawn Congress. The Philippine Shrimp Industry Inc. held this event in Bacolod City from 21-23 June.

Cabuyao Agri-Fair. SEAFDEC/AQD presented its freshwater aquaculture technologies in this fair which was organized by local authorities in Laguna province. The fair was held on 23-25 May.

Tilapia Congress. This was organized by DA, DTI, LGU of Pampanga province and held in San Fernando City, 02-04 March.

Maintaining a responsive library service

The SEAFDEC/AQD Library has a current collection of 34,724 titles and 53,911 volumes/copies. This makes it the biggest among the SEAFDEC departments.

The Library is open to the public, and its collection can be searched through the SEAFDEC/AQD website. Its special collection on brackishwater species makes it a unique one in Asia, having the best aquaculture collection.



SEAFDEC/AQD utilizes exhibits and fairs as a means to disseminate its research and development technologies to aquaculturists, extension workers, researchers and scientists, donors and policy makers and the general public.

Brackishwater species	Books, chapter from a book, proceeding papers	Journal/magazine articles	Posters	Total
Abalone	70	41	1	112
Filipiniana	602	2,636	0	3,238
Grouper	400	684	1	1,085
<i>Macrobrachium</i>	323	284	-	607
Milkfish	780	849	2	1,631
Mud crab	257	405	6	668
Rabbitfish	164	277	-	441
Sea bass	404	392	1	797
Seaweeds	306	276	2	584
Shrimp (<i>P. monodon</i>)	934	1,107	7	2,048
Tilapia	436	377	1	814

The Filipiniana materials are also considered excellent, and there is a good serial title collection on aquaculture up to the year 2000.

In terms of its services, 7,113 library users were noted, including about 900 from 104 different schools, government agencies and private sector; 43 queries from 13 countries were received and answered; and 13,148 global researchers visited the Library's online-public-access-catalogue or webOPAC.

In 2007, the Library may expand its coverage by networking with the International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC).



The SEAFDEC/AQD library has become a popular aquaculture reference resource for academic and research institutions both in the Philippines and abroad.

THE EXPONENT OF PHILIPPINE PROGRESS
SINCE 1900
MANILA BULLETIN
THE NATION'S LEADING NEWSPAPER
106 Years of Service to the Nation

BUSINESS BULLETIN

Sunday, December 17, 2006 <http://www.nib.com.ph> B-1

SEAFDEC helps RP expand crab program

By MELODY M. AGUIBA

The Philippines is continuously expanding its capacity to serve the growing mud crab market as the South East Asian Fisheries Development Center (SEAFDEC) has enabled crabs distribution in Luzon, Panay, and Mindanao provinces.

Dr. Joebert D. Toledo, SEAFDEC

aquaculture chief, said mudcrab seed production from hatcheries helped established by SEAFDEC has increased production rate from 26,000 crabs in 1998 to the present 205,000 crabs. These crabs have a 0.6 to 2 centimeter carapace width.

While SEAFDEC is international

research agency aimed to serve South East Asian countries, it has been collaborating with the Bureau of Fisheries and Aquatic Resources (BFAR) on crab propagation technologies considering crab's potential market expansion.

(Cont'd on page B-4)

THE PHILIPPINE
STAR
TRUTH SHALL PREVAIL

WEDNESDAY, JULY 5, 2006

B-7

Scientists turn to biotech to save ailing seaweed industry

By ROCELC C. FELIX

The export-oriented seaweed industry may soon get relief from the anticipated breakthrough in biotechnology researches

live food and bioremediation, cost-effective culture, harvesting and preservation techniques of green microalgae for crab an-

Servicing the mass media

Local and national mass media in the Philippines continued to avail of news and press releases produced by SEAFDEC/AQD.

In at least four occasions, members of the media were invited on a tour of the SEAFDEC/AQD research activities and facilities, and to meet and interview the Chief. News stories on these activities are usually published in the media.

In 2006, 8% of the stories about aquatic science printed in the newspapers featured SEAFDEC/AQD. Some radio programs also made use of SEAFDEC/AQD's news releases.

Exposure of SEAFDEC/AQD in the mass media

Coverage*	Total**	SEAFDEC/AQD
National	326	20 (6%)
Local	74	14 (19%)
Total	400	34 (8%)

* Subscription to 7 national daily newspapers and 1 local (Iloilo) paper

** Total number of aquatic science news/features

Conduct of in-house seminars

SEAFDEC/AQD continued to hold its in-house seminars as a forum for exchanging and updating of research results and information among its researchers and staff of other nearby institutions. In 2006, 15 seminars were held:

- 1) 08 February - "Viral nervous necrosis (VNN) as a critical infectious disease of grouper in the Philippines," Dr. Ikunari Kiryu (Fisheries Division, JIRCAS, Japan)
- 2) 08 June - "Reproductive suppression in the quahog clam *Mercenaria mercenaria* in high density protected fishery areas in Rhode Island," Dr. Michael A. Rice (Professor of Fisheries and Aquaculture, University of Rhode Island, USA)
- 3) 28 July - "Knowing R&D to do research properly," Dr. Flor J. Lacanilao (Retired UP Professor, Philippines)
- 4) 03 August 2006 - "Enhancing disease monitoring in shrimp through Geographical Information System (GIS) Application," Dr. Celia R. Lavilla-Pitogo (SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines)
- 5) 17 August 2006 - "Behavioral patterns of hatchery-produced juveniles, *Haliotis asinina* for stock enhancement: Predators, avoidance and search for food and shelter," Shelah Mae A. Buen-Ursua (SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines)
- 6) 23 August - "Including coastal resource users in fisheries management evaluation," Dr. Merlina N. Andalecio (IFPDS, CFOS, UP Visayas, Philippines)
- 7) 04 September - "Aquaculture at Kentucky State U," Dr. Tejinder S. Kochhar (Fulbright Senior Specialist and Distinguished Professor, Kentucky State University, USA)
- 8) 11 September - "Development of feeding mechanics in marine-fish larvae: Does prey size matter in the larviculture of marine fishes?" Dr. Ralph G. Turingan (Associate Professor, Florida Institute of Technology, Melbourne, Florida, USA)
- 9) 13 September - "Integrated mud crab culture system: A collaboration between the academe, private sector, and fishers of Visayan sea," Dr. Carlos Baylon (UP Visayas, Philippines)
- 10) 21 September - "Cell growth and nutritive value of the tropical benthic diatom *Amphora* sp. at varying nutrients, light intensity and location of culture,"

Milagros R. de la Peña (SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines)

- 11) 26 October - "Habitat utilization of 11 species of emperor fishes (Genus *Lethrinus*) for feeding in the coral reefs around the Yaeyama Islands, southern Japan," Dr. Katsuhiko Kiso (Seikai National Fisheries Research Institute, Ishigaki, Okinawa, Japan)
- 12) 09 November- "Life history of *Schizochytrium* sp. OT01: A thraustochytrid protist from mangroves of Panay, Philippines," Nathaniel L. Hepowit (SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines)
- 13) 15 November - "Effects of b-glucan on non-specific immune response in grouper, *Epinephelus coioides*," Mr. Rover John G. Tavarro (Division of Biological Sciences, College of Arts and Sciences, UP Visayas, Philippines)
- 14) 05 December - "Abalone farming in South Africa: Kelp resources and potential for on-farm seaweed production," Dr. Max Troell (Associate Professor, PhD Ecology, The Royal Swedish Academy of Sciences, Stockholm, Sweden)
- 15) 05 December - "Isolation of protoplasts from tissue fragments of Philippine cultivars of *Kappaphycus alvarezii* (Doty)," Dr. Ronelie Salvador (SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines)

Maintaining a regularly updated website

A virtually new SEAFDEC/AQD website was uploaded to the internet on August 21 and the visitor counter was reset to zero.

The website www.seafdec.org.ph contains new materials that include:

- 1) a dozen news items about mid-year activities
- 2) listing of research, technology verification and production programs and studies
- 3) a compilation of SEAFDEC/AQD's research output and journal publications 1976 to 2005
- 4) a list of award-winning papers and researchers 1987 to 2005
- 5) free downloads of at least 15 flyers, 7 reports, and a proceedings volume on chemical use in aquaculture
- 6) a new training course schedule and services including technical consultancy, disease diagnostics, hatchery-reared fry, feed mill tolling, etc.
- 7) new facilities, e.g. biotech laboratories
- 8) updated contact information

The website was updated again on 09 October and on December 11. Additional materials included an introduction to abalone hatchery and research and development and a

mini-website on Pew-sponsored research on marine biodiversity.

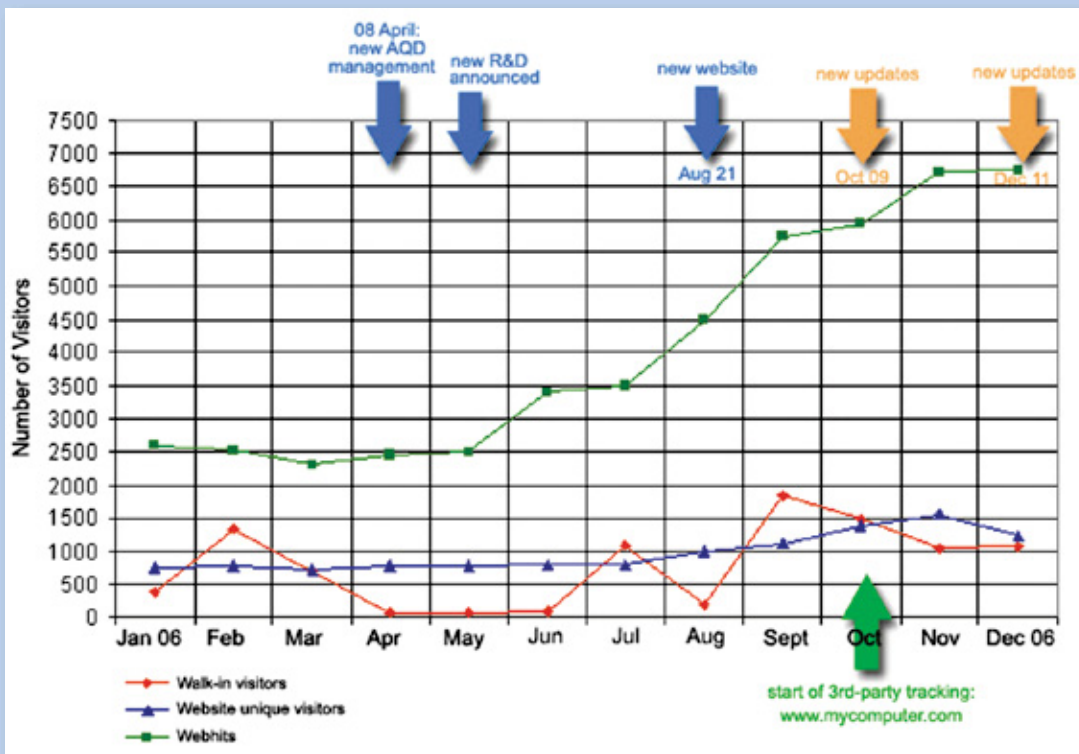
Viewership had been very encouraging, with virtual visitors matching the number of walk-in visitors to SEAFDEC/AQD, at more than a thousand each month. Web hits had also increased since SEAFDEC/AQD's new programs were announced and a new management team took over.

Based on the web statistics services of a third-party monitor (mycomputer.com), the web browsers had behaved as follows:

- arrived at the website by mostly typing or bookmarking SEAFDEC/AQD's URL address, which indicated some familiarity with the Department; and if searching, most had used the Yahoo search engine
- looked at the training schedule, list of specialists, and free downloadable publications, and returned to the site in less than a day to within three days.



The home page of the now very much up-to-date SEAFDEC/AQD website.



Visitors and web hits, SEAFDEC/AQD website www.seafdec.org.ph, 2006.

The SEAFDEC/AQD FishWorld

FishWorld is SEAFDEC/AQD's museum-aquarium visitor center. Established in July 2000, it serves as an information center on responsible aquaculture and fisheries, biodiversity conservation, environment protection and sustainable development.

FishWorld's science and environment program aims to educate the general public. Its primary target are elementary and high school schoolchildren.

In 2006, FishWorld received some 9,400 visitors, mostly students from 118 schools from Panay, Guimaras, and Negros provinces and all over the Philippines.

Adult visitors were also given tours. About 1,200 visited in the same period, and were oriented about hatcheries and the biotech facilities.

The FishWorld's Museum of Aquatic Biodiversity has a collection of about 3,000 species of fishes, mollusks, crustaceans, echinoderms, corals, seaweeds, and others. These serve as reference materials for students, teachers, and researchers.

On 25-29 July 2006, it hosted the annual Aquaculture Week Celebration. This event is part of SEAFDEC/AQD's environment education program where students and teachers from various elementary and secondary schools learn about aquaculture and the environment through competitions in science, art, writing, and livelihood projects. This year, 15 elementary schools with 94 contestants and 66 coaches and another 15 secondary schools with 66 contestants and 46 coaches participated in the contests.



The Annual Aquaculture Week highlights different science and science-based competitions among elementary and secondary school students. These serve as a strong incentive for students and teachers to assist in promoting responsible aquaculture principles and practices.



FishWorld is now recognized as a rescue and rehabilitation center for endangered marine animals. In December last year, five marine turtles that had been in SEAFDEC/AQD's tanks for a month to a year were loaded onto a large outrigger boat and released in the Sulu Sea in an event dubbed as "Panaw Pawikan."



SEAFDEC/AQD welcomes new Chief

Dr. Joebert D. Toledo is the new Chief of SEAFDEC/AQD.

The SEAFDEC Council appointed Dr. Toledo as SEAFDEC/AQD Chief effective 08 April 2006 in its 38th Meeting in Brunei Darussalam on 18-21 April 2006. The post has a term of two years.

Dr. Toledo obtained his Bachelor of Science in Fisheries degree from the University of the Philippines Diliman. He finished both his Masters in Science in Aquaculture and Doctorate in Agriculture in Applied Biological Science at the Hiroshima University in Japan. He joined SEAFDEC/AQD in 1981 as research assistant, eventually attaining the honored position of Scientist II in 2002.

As a SEAFDEC/AQD researcher, he conducted various research projects in fish seed production, par-

ticularly in groupers. He published many research papers and trained many farmers and government officers in Southeast Asia. In 1992 through 1995, he was seconded as Marine Fish Seed Production Expert to the Department of Fisheries of Brunei Darussalam.

Dr. Toledo has shared his expertise with the private sector. He served as technical and management consultant, or partner of various aquaculture-related companies in the Philippines and in other Asian countries.

In recognition of his exemplary scientific work, the Philippine scientific community has awarded Dr. Toledo the following: (1) 2001 Dr. Elvira Tan Memorial Award for Best Published Paper in Marine Fisheries; (2) 2002 Department of Agriculture Award for R&D and (3) 2002 Gawad Pangisdaan Award for Outstanding Fisheries Professional.



In a simple induction ceremony held at the SEAFDEC/AQD Tigbauan Main Station and presided over by Philippine Department of Agriculture Undersecretary Salvador Salacup (left), Dr. Joebert D. Toledo (center) is inducted as the new SEAFDEC/AQD Chief effective 08 April. Looking on is SEAFDEC/AQD Deputy Chief Dr. Koichi Okuzawa.

SEAFDEC/AQD Officers



Dr. Joebert D. Toledo
Chief



Dr. Koichi Okuzawa
Deputy Chief



Dr. Evelyn Grace de Jesus-Ayson
Head, Research Division



Mr. Renato F. Agbayani
Head, Training and Information Division



Dr. Neila Sumagaysay-Chavoso
Head, Technology Verification and Commercialization Division



Atty. Jerry T. Opinion, CPA
Head, Administration and Finance Division



Dr. Nerissa D. Salayo
Head, Manila Office



Mr. Albert G. Gaitan
Head, Igang Marine Sub-station



Dr. Ma. Lourdes C. Aralar
Head, Binangonan Freshwater Station



Ms. Jocelyn M. Ladja
Head, Dumangas Brackishwater Station

SECTION HEADS

Fish Health Section

Training Section

Information Services Section:

Development Communication Unit

Library Services Unit

FishWorld

Engineering Section

General Services Section

Human Resources Management Section

Budget Cashiering Section

Accounting Section

Dr. Celia L. Pitogo

Ms. Kaylin G. Corre

Ms. Milagros T. Castaños

Ms. Amelia T. Arizola

Dr. Teodora U. Bagarinao

Engr. Salvador Rex A. Tillo

Ms. Agnes C. Lacuesta

Ms. Didi B. Baticados

Mr. Juan L. Garin Jr.

Ms. Renee L. Valencia

RESEARCH PROGRAM LEADERS

Integrated Mollusk Program

Mud Crab and Shrimp Domestication Program

Marine Fish Program

Seaweed Strain Improvement Program

Smallholder Freshwater Aquaculture Program

Mr. Armando C. Fermin

Dr. Emilia T. Qunitio

Dr. Felix G. Ayson

Dr. Anicia Q. Hurtado

Dr. Ma. Lourdes C. Aralar

Finances

SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER AQUACULTURE DEPARTMENT

Statement of Source and Application of Funds

01 January to 31 December 2006

SOURCE OF FUNDS		APPLICATION OF FUNDS	
	Philippine Peso (PhP)		
Government of the Philippines	100,000,000	General Operating Expenses	
		Personnel Services	PhP 40,437,160
		Maintenance and Operations	32,635,493
		Capital Outlay/Repairs	11,185,071
			84,257,724
Government of Japan Trust Fund		Project Expenses	
Development of Fish Disease Surveillance System for Aquatic Animals	5,668,750	Research Division	17,182,878
Stock Enhancement for Threatened Species of International Concern	2,111,559	Training and Information Division	1,553,623
Promotion of Sustainable Aquaculture in the ASEAN Region (Special 5-year Program)	3,488,410	Technology Verification and Commercialization Division	5,939,709
MFRDI - Regional Surveys and Study	494,255		24,676,210
GoJ Committed Funds from Prior Year	3,659,503	Government of Japan Trust Fund Projects	
	15,422,477	Development of Fish Disease Surveillance System for Aquatic Animals	4,997,856
		Stock Enhancement for Threatened Species of International Concern	1,335,792
		Promotion of Sustainable Aquaculture in the ASEAN Region (Special 5-Year Program)	2,881,461
		MFRDI Regional Surveys and Study	475,924
		GoJ Committed Funds/Advances	5,731,444
			15,422,477
External Grants		Externally Funded Projects	
World Fish Center	50,000	ASEAN Foundation (HRD for Sustainable Development of Fisheries in the BIMP-EAGA Region)	1,408,473
Japan International Research Center for Agricultural Sciences (JIRCAS)	113,068	World Fish (Milkfish Technology Review and Screening)	56,165
I. Kiryu	11,849	Republic of Palau (Aquaculture Development Consultancy)	1,165,572
Fisheries Research Agency (FRA)	614,384	NFRDI - Growth Performance of GET-EXCEL Tilapia	39,311
ASEAN Foundation	1,191,263	ACIAR Grouper Projects (In-country Research Project to Develop Diagnostic Kit)	1,771
Republic of Palau	1,091,041	JIRCAS (Reproductive and Larval Performance of Rabbitfish, Siganid)	136,067
Department of Agriculture (DA), Philippines	350,000	KIRYU (Pathogenesis and Control of Subclinical Infection)	1,080
DA Bureau of Fisheries and Aquatic Resources (BFAR) and National Fisheries Research and Development Institute (NFRDI)	3,000,000	European Commission - CAMS (Mud crab and <i>Scylla</i> Species)	469,260
	6,421,605	ASEM - Univ. of Ghent-ASEM Aquaculture Platform Workshop	140,670
		UNESCO - ASPACO-Guidebook to Philippine Mangroves	539
Internally Generated Funds		LGU Antique - Collaborative Project	482,664
Income - Research Division	3,263,857	DOST 10 - Collaborative Project	8,714
Income - Training and Information Division	2,213,957	Cavite State University - CVSU-NC-SEAFDEC/AQD Staff Development Project	284,240
Income - Technology Verification and Commercialization Division	192,219	FRABEL - Production of Big Head Carp Fry and Fingerling	106,427
Income - Administrative and Finance Division	5,604,044	FRA - Comparison of Characteristics of KHV Isolates	861,401
Income - Management Office	102,945		5,162,354
	11,377,022	DA-BFAR-NFRDI - Aquaculture Biotechnology Projects	9,748,928
Committed Funds from Prior Year	13,792,518		
		Committed Funds	
		Advances for on-going activities	2,349,535
		Jobs-in-progress - capital outlay/repairs	5,396,394
			7,745,929
Total Funds	PhP 147,013,622	Total Application of Funds	PhP 147,013,622

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 conducts research on fisheries problems; generates appropriate fisheries technologies; trains researchers, technicians, fishers and aquafarmers, and managers; disseminates information on fisheries science and technologies; and recommends policies pertaining to the fisheries sector.

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

- The Training Department (TD) in Samut Prakarn, 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 (MRFRDM) in Kuala Trengganu, Malaysia (1992) for the development and management of fishery resources in the exclusive economic zones of SEAFDEC member countries.

SEAFDEC/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

SEAFDEC/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.

SEAFDEC Aquaculture Department
5021 Tigbauan, Iloilo, Philippines
P.O. Box 256, 5000 Iloilo City, Philippines
Tel.: (063-33) 511-9171; 3362891; 336-2965
Fax: (063-33) 335-1008; 511-8709
Email: aqchief@aqd.seafdec.org.ph
Website: <http://www.seafdec.org.ph>



Tigbauan Main Station



Dumangas Brackishwater Station



Igang Marine Station



Binangonan Freshwater Station

