

SEAFDEC/AQD
Highlights 2015



Southeast Asian Fisheries Development Center
AQUACULTURE DEPARTMENT
www.seafdec.org.ph

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2015 SEAFDEC/AQD HIGHLIGHTS

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Front cover photo and layout by IT Tendencia

Inside cover photos (top-bottom): seaweeds *Kappaphycus* (AQD Archive), milkfish *Chanos chanos* (IT Tendencia), mud crab *Scylla serrata* (IT Tendencia), abalone *Haliotis asinina* (J Zarate), tiger shrimp *Penaeus monodon* (IT Tendencia)



Message of the Chief

Aquaculture is the fastest growing food production sector with an average annual growth rate of 7.8% from 1990 up to the present. One in every two fish that we see in the market today is produced in farms. Nearly 90% of the total global aquaculture production comes from Asia and roughly 26% of these come from the ASEAN Region. It is also noteworthy that five of the top 15 aquaculture producing countries are in Southeast Asia.

Several factors contributed to the increase in aquaculture production in the region, which includes the availability of technologies to breed and grow aquaculture species. SEAFDEC/AQD has contributed significantly to the development of these technologies which started with shrimp and milkfish in the 1970s. Currently, SEAFDEC/AQD, in collaboration with DOST-PCAARRD and UPV, is refining aquaculture technologies on mud crab, abalone, shrimp and oyster.

The further expansion of aquaculture, however, is faced with some challenges. The increasingly abnormal global climate lately is one of these factors. In the tropics, even small temperature changes in seawater will have profound effects on the reproduction and early development of cultured species and increase the occurrence of diseases. Ocean acidification that will affect the

shellfish industry may also disrupt the marine food web that supports various organisms, which supply fish meal and fish oil for aquaculture feeds.

SEAFDEC/AQD has started to look at the impact of global warming on the reproduction and early development of some important aquaculture species. The Department has likewise included climate change and its impact on fisheries and the aquaculture industry in the curriculum of its training courses.

The increasing dependence of aquaculture feeds on terrestrial crops and wild fish as ingredients is another key challenge faced by the industry. To address these issues, SEAFDEC/AQD worked together with SEAFDEC Secretariat in Thailand and the Department of Fisheries in Myanmar, and the ASEAN Foundation to convene the regional technical consultation on the use of alternative ingredients in aquaculture feed formulation.

Increasing intensification of aquaculture operations to produce more fish has also seen the emergence of new diseases and disease outbreaks. SEAFDEC/AQD in collaboration with SEAFDEC Secretariat and BFAR will convene a regional, technical consultation on EMS/AHPND (Early Mortality Syndrome/ Acute

Hepatopancreatic Necrosis Disease) and other Transboundary Diseases to share experiences and provide updates on R&D approaches on their management and prevention.

Finally, to improve the quality of life and alleviate poverty in rural areas, SEAFDEC/AQD is promoting community-based or family participation in both aquaculture and resource enhancement activities. It is envisioned that poor families will benefit through their engagement in aquaculture activities. This is another priority program with support from the Government of Japan Trust Fund (GOJ-TF), Japan International Research Center for Agricultural Sciences (JIRCAS) and Research Institute for Humanity and Nature (RIHN).

The Department is moving towards ensuring the sustainability of aquaculture; which, can only be achieved with the cooperation of all sectors. I therefore urge the scientific community, the governments of ASEAN member states, and in the case of the Philippines, all government agencies, the farmers and the private sector to work hand in hand to achieve this objective.



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

THE 2015 MANAGEMENT GROUP



Seated (left-right): SEAFDEC/AQD Chief Dr. Felix Ayson, Administration and Finance Division Head Ms. Kaylin Corre and Deputy Chief Dr. Takuro Shibuno **Standing (left-right):** Technology Verification and Demonstration Division Head Dr. Fe Dolores Estepa, Training and Information Division Head Dr. Ma. Junemie Hazel Ramos and Research Division Head Dr. Evelyn Grace Ayson

New Collaborations in 2015

ACADEME

University of Antique (Sibalom, Antique): On-the-Job training program (28 January 2015 to 27 January 2016)

Western Visayas College of Science and Technology (La Paz, Iloilo City): Collaboration on instruction, research, training and extension programs in fisheries, aquatic and related sciences (10 February 2015 to 9 February 2020)

Aklan State University (Banga, Aklan): Technical assistance for mud crab hatchery and nursery operations (8 March 2015 to 7 March 2016)

Universiti Malaysia Sabah (Kota Kinabalu, Sabah, Malaysia): Exchange of scientist/experts for research, symposia; joint research activities; exchanges of informational materials on education, training and research matters (17 March 2015 to 16 March 2020)

Zamboanga State College of Marine Science and Technology (Zamboanga City): Technical assistance for mud crab hatchery and nursery operations (26 March 2015 to 25 March 2016)

Colegio de las Hijas de Jesus (Ledesma St., Iloilo City): Provide necessary activities for the students to enrich their learning in Biology, Chemistry and Physics (27 March 2015 to 26 March 2019)

Northern Iloilo Polytechnic State College (Concepcion, Iloilo): Technical assistance for sandfish hatchery and nursery operations (22 May 2015 to 21 May 2017)

University of Antique, College of Fisheries, Tario-Lim Memorial Campus (Tibiao, Antique): Collaboration on Research, Training and Extension programs (29 July 2015 to 28 July 2020)

Mindanao State University-Naawan Campus (Naawan, Misamis Oriental): Technical assistance for abalone hatchery, nursery and grow-out operations (4 August 2015 to 3 August 2016)

St. Vincent Ferrer Seminary (Jaro, Iloilo City): Provide necessary activities for the students to enrich their learning in Biology, Chemistry and Physics (1 September 2015 to 31 August 2017)

Western Philippines University (San Juan, Aborlan, Palawan): Technical assistance for abalone hatchery, nursery and grow-out operations (4 September 2015 to 3 September 2016)

Iloilo State College of Fisheries (Tiwi, Barotac Nuevo, Iloilo): Collaboration on Research, Training and Extension programs (11 September 2015 to 10 September 2020)

Capiz State University Sopian Satellite College (Sopian, Capiz): On-the-Job training program (26 October 2015 to 25 November 2015)

University of Santo Tomas (Sampaloc, Metro Manila): Mass Production of dsRNA to mitigate WSSV infection in *Penaeus monodon* (26 October 2015 to 25 October 2017)

GOVERNMENT & NON-GOVERNMENT ORGANIZATIONS

Local Government Unit of Nueva Valencia, Municipal Fisheries and Aquatic Resources Management Council of Nueva Valencia and Pandaraonan Unified Association (Nueva Valencia, Guimaras): Community-based sea ranching of sandfish in Nueva Valencia, Guimaras (9 January 2015 to 8 January 2019)

Food and Agriculture Organization of the United Nations (Rome, Italy): Digitization, Open Access Deposition and the Provision of URL to existing ASFA records of SEAFDEC/AQD Publications (16 February 2015 to 15 February 2016)

Protected Area Management Board for the Sagay Marine Reserve (Sagay City, Negros Occidental): Undertake research on some reef mollusks, echinoderms, seaweeds, seagrasses, finfishes and socioeconomics (10 March 2015 to 9 March 2020)

Japan International Research Center for Agricultural Sciences (Tsukuba, Ibaraki, Japan): (1) On-farm strategies for promoting integrated multi-trophic aquaculture (IMTA) through sustainable livelihood approach (SLA) in Guimaras, Philippines and (2) Verifying a combination of IMTA in a marine pen culture system (10 April 2015 to 29 February 2016)

Bureau of Fisheries and Aquatic Resources (Diliman, Quezon City): Conduct of training of trainers for the ASEAN shrimp good aquaculture practices (25 May 2015 to 24 June 2016)

Department of Science & Technology-Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development [DOST-PCAARRD] (Los Baños, Laguna): Implementation of the project on prevention and mitigation of diseases in mud crab culture (1 July 2015 to 31 December 2017)



PHOTO COURTESY OF FGAYSON

Universiti Malaysia Sabah Vice Chancellor Prof. Datuk Dr. Mohd. Harun Abdullah and AQD Chief Dr. Felix Ayson

Provincial Government of Palawan (Puerto Princesa City, Palawan): Implementation of the seaweed upscaling program (14 July 2015-until project completion)

Municipality of Leganes (Leganes, Iloilo): Rental/use of Leganes ponds for SEAFDEC/AQD's research project/s (1 October 2015 to 30 September 2018)

DOST-PCAARRD (Los Baños, Laguna): Sustainable production of mud crab through selective breeding (2015-2018)

PRIVATE SECTOR

Trifon P. Macarayan/Mega Fishing Corporation (Zamboanga City): Technical assistance for mud crab hatchery and nursery operations (26 March 2015 to 25 March 2016)

Mr. Rufino S. Suelo (Zarraga, Iloilo): Test trial of soy-based artificial feed for milkfish in a freshwater impounding facility (1 April 2015 to 1 October 2015)

Meehan the Fine Food Group, Inc. (Candon City, Ilocos Sur): Technical assistance for abalone hatchery, nursery and grow-out operations (28 July 2015 to 27 July 2016)

Ayala Corporation (Makati City): Grow-out culture of abalone in Brgy. Jolog, Estancia, Iloilo for the Uswagon Homeowners Association (October 2015 to May 2016)

Santeh Feeds Corporation (Mandaluyong City, Manila): Test trial of artificial feed for mud crab in a brackishwater facility (1 November 2015 to 31 October 2016)

Research and Development Programs in 2015

Study Title	Main Proponent	Collaborating Partner/s*	
THEMATIC PROGRAMS			
Producing Quality Seed for Sustainable Aquaculture			
1	National Mud Crab Science and Technology Program: Program Title A: Refinement of mud crab hatchery technology, Project Title: Sustainable production of mud crab through selective breeding	ET Qunitio	DOST-PCAARRD ¹
2	Domestication of silver therapon (<i>Leiopotherapon plumbeus</i>) (Perciformes: Terapontidae): I. Nutritional evaluation of wild-sourced and hatchery-bred stocks for feed development	FA Aya	
3	Refinement of sandfish hatchery techniques	FG Ayson	
4	Improvement of the performance of captive <i>Penaeus monodon</i>	FDP Estepa	DOST-PCAARRD
5	Genetics for sustainable milkfish aquaculture. I. Development and application of molecular markers in milkfish broodstock management	MR Eguia	DOST/UPD-IB ²
6	National Mud Crab Science and Technology Program: Program Title A: Refinement of mud crab hatchery technology, Project Title 2: Improvement of larval rearing protocol	ET Qunitio	DOST-PCAARRD
7	Refinement of abalone culture techniques to enhance growth, meat quality and maturation Subtitle 1: Experimental hybridization of Philippine native abalone species; <i>Haliotis asinina</i> , <i>H. glabra</i> , <i>H. ovina</i> , <i>H. varia</i> , <i>H. planata</i> Subtitle 2: Triploid induction of <i>Haliotis asinina</i>	MR de la Peña	DOST-PCAARRD
8	Increasing juvenile production through improved hatchery culture techniques Subtitle 1: Use of chemical cues (positive ions, algal extracts) to improve settlement rate Subtitle 2: Improved culture system with the use of new tank design and orientation of plates Subtitle 3: Use of anaesthetic agents as muscle relaxant for efficient sorting and harvesting of abalone juveniles	MR de la Peña	DOST-PCAARRD
9	Hatchery and nursery operation for blue swimming crab, <i>Portunus pelagicus</i> : Project 2: Development of nursery technology for the blue swimming crab, <i>Portunus pelagicus</i>	FDP Estepa	DOST-PCAARRD
10	Studies on seed production and release of seahorses for stock enhancement (PhD Dissertation)	SMB Ursua	JSPS ³
11	National Blue Swimming Crab R&D Program: Program Title A: Hatchery and nursery operation for blue swimming crab <i>Portunus pelagicus</i> , Project Title: Improvement of larval rearing protocol	ET Qunitio	DOST-PCAARRD
12	Improved larval rearing protocol for silver therapon (<i>Leiopotherapon plumbeus</i>): Larval diets, optimal stocking density and weaning strategies under controlled conditions	FA Aya	
13	Application of strategies for reduction of cannibalism in the mud crab nursery	FDP Estepa	DOST-PCAARRD

Study Title		Main Proponent	Collaborating Partner/s*
14	Refinement of hatchery techniques for the donkey's ear abalone <i>Haliotis asinina</i> Subtitle 1: Improvement of fecundity and seed quality of breeders recently acquired from the wild Subtitle 2: Evaluation of genetic stocks for selective breeding of abalone Subtitle 3: Increase survival rate of veliger larvae through improvement of harvest and incubation protocol	MR de la Peña	DOST-PCAARRD
15	Development of techniques for sustainable production of marine annelids as feed for mud crab broodstock	VR Alava	DOST-PCAARRD
16	Production of juvenile and marketable size tropical abalone <i>Haliotis asinina</i> in tanks: Microparticulate diet as alternative feed in abalone hatchery production	MB Teruel	
17	Nursery rearing techniques for seed production of <i>Kappaphycus</i> "seedlings"	MRJ Luhan	
18	Broodstock management and conditioning for the oyster <i>Crassostrea iredalei</i> to maximize production	JM Ladja	DOST-PCAARRD
19	Refinement of hatchery and nursery rearing techniques for the production of quality oyster <i>Crassostrea iredalei</i> seedstock: I. Optimization of induced spawning methods II. Improvement of culture techniques	JM Ladja	DOST-PCAARRD
20	Mass production of sex-reversed and mixed sex Nile tilapia (<i>Oreochromis niloticus</i>), and hybrid red tilapia and catfish (<i>Clarias</i> spp.) fingerlings	DM Reyes Jr.	
21	Large-scale production of donkey's ear abalone, <i>Haliotis asinina</i> juveniles	D Catedral (NC Bayona)	
22	Development of ice-ice resistant strains of <i>Kappaphycus</i> and technology for reduction of epiphytes	MRJ Luhan	ACIAR ⁴
23	Outplanting of <i>Kappaphycus</i> propagules in the province of Palawan	MRJ Luhan	LGU Palawan ⁵
Promoting Healthy and Wholesome Aquaculture			
24	Evaluation of enriched <i>Ulva lactuca</i> and <i>Sargassum oligocystum</i> as feed ingredients in abalone <i>Haliotis asinina</i> diet	RB Santizo	
25	Quantitative amino acid requirements of juvenile Asian sea bass (<i>Lates calcarifer</i> Bloch): Requirements for leucine and isoleucine	RMA Cabrera	
26	Distillers for dried grains with solubles (DDGS) evaluation as protein ingredient for diets of milkfish, <i>Chanos chanos</i> cultured in floating net cages	RE Mamauag	
27	Growth and survival of milkfish (<i>Chanos chanos</i>) fed immunostimulant-containing feeds stocked at two densities in cages in ponds in Bulacan, Philippines	VR Alava	
28	Effects of immunostimulant-containing diets on growth, survival, and immunity-stimulating capacity of Nile tilapia (<i>Oreochromis niloticus</i>) in low volume, high density (LVHD) cages in Taal Lake, Batangas	MRR Eguia	
29	Evaluation of milkfish by-product hydrolysate as ingredient in juvenile grouper, <i>Epinephelus coioides</i> diets	RE Mamauag	
30	Improvement of feeds and management practices for mud crab grow-out culture: Pilot-scale production of pellets suitable for mud crab	RM Coloso	DOST-PCAARRD
31	Feed development for the golden pompano, <i>Trachinotus blochii</i>	MR Catacutan	

Study Title		Main Proponent	Collaborating Partner/s*
32	Use of soybean meal and soy protein concentrate as alternatives to fish meal in practical feeds for milkfish, <i>Chanos chanos</i>	RM Coloso	United Soybean Board
33	Establishment of Philippine shrimp pathogen bio-bank and online biosurveillance information resource	EC Amar	DOST-PCAARRD
34	Establishment of sanitary quality of oysters and their culture environments	RV Pakingking Jr.	DOST-PCAARRD
35	Development of shrimp pathogen diagnostic tools using nested PCR and lateral flow strip biosensors coupled with a mobile app and cloud-based information management	LD de la Peña	DOST-PCAARRD
36	Quantitative and qualitative analyses of the bacterial microbiota of tilapia (<i>Oreochromis niloticus</i>) cultured in earthen ponds as tool for investigating emerging and re-emerging diseases of tilapia in the Philippines	RV Pakingking Jr.	DOST-NRCP ⁶
37	Novel strategies to reduce disease incidence in mud crab hatchery and grow-out	EC Amar	DOST-PCAARRD
38	Production characteristics of the giant freshwater prawn <i>Macrobrachium rosenbergii</i> cultured in cages using different grow-out management strategies	MLC Aralar	
39	Evaluation of practical and eco-friendly supplemental feeding schedules for Nile tilapia (<i>Oreochromis niloticus</i> L.) in cages in Laguna de Bay, Philippines	MRR Eguia	
40	Production of juvenile and marketable size tropical abalone <i>Haliotis asinina</i> in concrete land-based tanks: Sub-project 3: Test of refined formulated feed for the grow-out culture of tropical abalone, <i>Haliotis asinina</i> Linne in concrete land-based tanks: Use of binders and application of different feed forms	MB Teruel	
41	Performance of hatchery-bred <i>Penaeus indicus</i> in grow out culture conditions	SS Avanceña	
42	Improving pond production of <i>Gracilariopsis heteroclada</i> Zhang & Xia by fertilization of the starting plant materials	SS Avanceña	
43	Commercialization of soft-shell crab production	ET Qunitio	
44	Production of rabbitfish (<i>Siganus guttatus</i>) in semi-intensive grow-out culture using SEAFDEC/AQD diet in brackishwater ponds	EB Coniza	
45	Demonstration of semi-intensive grow-out culture of grouper <i>E. fuscoguttatus</i> and <i>E. coioides</i> fed SEAFDEC/AQD phased-diet in brackishwater pond	EB Coniza (MR Catacutan)	
46	Prevention and mitigation of diseases in mud crab culture	EA Tendencia (D Catedral)	DOST-PCAARRD
Maintaining Environmental Integrity through Responsible Aquaculture			
46	Culture of <i>Caulerpa</i>	MRJ Luhan	
47	Giant freshwater prawn culture in biofloc system	MLC Aralar	
48	Grow-out of abalone in small islands and/or community	MJHL Ramos	DOST-PCAARRD
49	Refinement of existing oyster grow-out techniques	MJHL Ramos	DOST-PCAARRD
50	Culture trial for sandfish <i>Holothuria scabra</i> in ponds and sea ranch	JP Altamirano	ACIAR
51	Impact of aquaculture in a freshwater environment: Biodiversity of aquatic fauna at the east and west cove of the Binangonan Freshwater Station	MLC Aralar	

Study Title	Main Proponent	Collaborating Partner/s*
Meeting Social and Economic Challenges in Aquaculture		
52	Study 1: Market and industry study of selected high-value indigenous fish species in the Philippines Study 2: Consumption of selected high-value indigenous fish species in the Philippines [i.e. giant trevally or maliputo (<i>Caranx ignobilis</i>), silver therapon or ayungin (<i>Leiopotherapon plumbeus</i>), lobed river mullet or ludong (<i>Cestraeus</i> sp.) and Tapiroid grunter or piguek (<i>Mesopristes</i> sp.)]	ND Salayo & CF Aya
53	Coastal area capability development through community-based stock enhancement in New Washington, Aklan, Philippines	JP Altamirano
54	Demonstration and adoption of larval and nursery rearing of giant freshwater prawn <i>Macrobrachium rosenbergii</i> among small-holder fish farmers in Laguna de Bay	EV Aralar
55	On-farm strategies for promoting IMTA through Sustainable Livelihood Approach (SLA) in Guimaras, Philippines	ND Salayo/ M Kodama
GOJ TRUST FUND PROGRAM - The Promotion of Sustainable Aquaculture and Resource Enhancement in Southeast Asia (ASEAN-SEAFDEC FCG Mechanism)		
Reinforcement and optimization of fish health management and effective dissemination in the Southeast Asian Region		
56	Enhancement of vaccine efficacy for the prevention of viral nervous necrosis in high value marine fish	RV Pakingking Jr.
57	Establishment of protective measures against persistent and emerging parasitic diseases of tropical fish	GE Pagador
58	Application of adjuvants, carriers and RNAi technology to enhance the antiviral immune response of shrimp to WSSV	EC Amar
59	Epidemiology of the Early Mortality Syndrome (EMS)/acute hepatopancreatic necrosis disease (AHPND) in <i>Penaeus monodon</i>	EA Tendencia
60	Development and acceleration of rapid and effective fish and shrimp health management	LD de la Peña
Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources		
61	Use of plant-based protein sources in tilapia feeds for improved production traits	FA Aya
62	Responsible aquaculture through aquasilviculture	EA Tendencia
63	Community-based integrated production of abalone <i>Haliotis asinina</i> and sandfish <i>Holothuria scabra</i> through culture, sea ranching and stock enhancement	ND Salayo
64	Promotion of resource enhancement of seahorses	SMB Ursua

SEAFDEC/AQD's COLLABORATING PARTNERS

¹**DOST-PCAARRD** - Department of Science & Technology-Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development

²**UPD-IB** - University of the Philippines Diliman-Institute of Biology

³**JSPS** - Japan Society for the Promotion of Science

⁴**ACIAR** - Australian Centre for International Agricultural Research

⁵**LGU Palawan** - Local Government Unit of Palawan

⁶**DOST-NRCP** - National Research Council of the Philippines

⁷**RIHN** - Research Institute for Humanity and Nature

⁸**JIRCAS** - Japan International Research Center for Agricultural Sciences

⁹**GOJ-TF** - Government of Japan-Trust Fund

Producing Quality Seed for Sustainable Aquaculture (QS)

PHOTO BY DEVCOM



Annual monitoring of milkfish broodstock at SEAFDEC/AQD

RATIONALE

The sustainable production of aquatic species for human consumption depends mainly on the availability of good quality seedstock apart from the adoption of optimal husbandry techniques. With the lack of good broodstock sources, intensification of aquaculture systems and environmental challenges such as those resulting from climate change; genetic quality and culture management should be considered as equally important in ensuring a steady yield of good quality seeds and later, marketable products from aquaculture. Hence, through SEAFDEC/AQD's *Producing Quality Seed for Sustainable Aquaculture* program, activities that determine optimal conditions and methods in continually producing sufficient, quality seedstock are being pursued. Researches primarily involve conventional means of stock improvement such as domestication, broodstock management, strain evaluation and selective breeding or genetic improvement of economically important freshwater and marine species. Advanced methods such as molecular marker assessments are likewise being integrated into stock management. These technologies shall be verified and once mature, shall be packaged as viable or cost-effective methods for broodstock and seed production. The ultimate aim is not only to develop and verify technical knowledge but also to train and inform industry stakeholders, especially fish farmers, of protocols for seed production and source of seeds especially of improved stocks.

Generate, verify and promote technologies to ensure the sustainable production of quality seedstock for aquaculture as well as for stock enhancement

OBJECTIVES

1. Develop good quality broodstock for traditional and emerging species through domestication, genetic management and nutritional intervention
2. Improve quality and production of seedstock through the refinement of hatchery and nursery management methods
3. Develop schemes for the production, management, maintenance and dissemination of genetically selected and improved stocks
4. Produce sufficient seedstock through the adoption of economically viable seed production systems
5. Build the capability of fish farmers and other industry stakeholders in appropriate breeding and larval rearing technologies through training, extension and information dissemination

Develop good quality broodstock and implement proper stock management protocols



PHOTOS BY M DELAPENA

Abalone broodstock conditioning tanks (left) and identification & tagging of broodstock (right)

Broodstock quality is an important factor that must be considered in aquaculture seed production or in stock enhancement. It is recommended that stocks must be genetically diverse to ensure fitness of larvae produced when farmed/released in specific environments. For aquaculture, the preference is for improved seedstock

Highly genetically diverse broodstock ensure fitness of seedstock for aquaculture

for better yield as these are grown to marketable sizes. For stock release, the seeds produced by quality spawners ideally needs to be genetically similar to the stocks in the receiving area to maintain the genetic integrity of the population in the enhancement site. Supportive breeding, or the use of broodstock from the enhancement site is often suggested to prevent further deterioration of the stocks in the release area. The following are the accomplishments of all the R&D activities that address the first objective.

Commercial species

Molecular markers that will identify stocks and consequently aid in determining genetic quality were used in several commercial aquaculture species. SEAFDEC/AQD, in collaboration with the University of the Philippines, Tohoku

University in Japan and the Philippine Department of Science and Technology (DOST) as funding agency, conducted studies on the development of quality milkfish, abalone, oyster and mud crab broodstock through molecular marker-aided stock monitoring and management.

Microsatellite DNA (msDNA) markers were developed and used in the Philippine milkfish *Chanos chanos* stocks. Samples ($n \leq 50/\text{stock}$) from sixteen populations of wild and/or hatchery-bred broodstock (including stocks from Indonesia that were used in local commercial grow-out operations) were genetically characterized. After optimizing DNA extraction and PCR amplification protocols, about 55 loci screened from 78 potential microsatellite markers were noted to be polymorphic. Nine microsatellite marker loci were finally identified as utilizable and were applied in delineating stocks. These nine novel microsatellite markers were used in assessing milkfish samples from three wild populations -- Claveria (CLA), Currimao (CUR), Camiguin (CAM); 11 local hatchery stocks -- SEAFDEC Integrated Hatchery (SIH), SEAFDEC Big Hatchery-Igang batches 1 and 2 (SBH-I1 and SBH-I2), SEAFDEC Big Hatchery-Dumangas (SBH-D), Hautea Hatchery (HH), Sual Pangasinan Hatchery (SPH), BFAR Dagupan Hatchery (BDH), BFAR Bohol Hatchery (BoH), BFAR Palawan Hatchery (PAL), Zambales Hatchery-P₀ (ZH-P₀), Zambales

Hatchery-F₁ (ZH-F₁); and a hatchery stock from West Java in Indonesia (WJH). An Indonesian stock was included since in the Philippines, Indonesian milkfish fingerlings are imported and farmed for having purportedly better production traits. Genetic diversity indices such as expected heterozygosity (He) and allele frequency (A) ranged from 0.655 to 0.697 and 9.2 to 11.1, respectively. AMOVA showed significant but low genetic differentiation among the milkfish

Significant but low genetic diversity exists among milkfish population

population ($F_{ST} = 0.013$; $P = 0.000$) because much of the variation is attributed to intrapopulation differences (98.6%). The oldest hatchery stock SIH (30-35 years) had relatively moderate genetic variability ($He = 0.66$, $A = 10.6$), which is lower than that of 5-year old SBH-I1 ($He = 0.687$, $A = 11.5$) considering that both stocks originally came from the same source in the wild. A reduction in genetic diversity was seen when a local hatchery stock (ZH-P₀; $He = 0.66$ and $A = 10.8$) was monitored after one generation (ZH-F₁; $He = 0.65$, $A = 9.3$). Finally, the Indonesian stock WJH had genetic variability levels ($He = 0.66$; $A = 10.5$) comparable with local stocks. Results of these genetic analyses need to be considered in the context of

promoting effective milkfish broodstock management practices for the production of good quality seed stock.

As for the abalone, aside from the current SEAFDEC/AQD hatchery stock, wild stocks from Pangasinan, Palawan, Zamboanga del Sur, Masbate, Sagay, Zamboanga del Norte and Cebu were collected and five families per stock were continuously being produced for genetic assessment. Some families from these stocks were evaluated both for genetic diversity (using COI and COII mtDNA markers and six novel msDNA markers) as well as growth-related traits. Molecular work on the abalone stocks will be continued in 2016. Meanwhile, based on production characteristics, to date, the abalone hatchery stock had the highest fecundity at 1,028,500 eggs/female (n=2) and the Pangasinan stock had the lowest fecundity at 273,000 eggs (n=9). Larvae spawned from Palawan breeders have the highest settlement rate of 1.78% (n=4) and the Pangasinan stock has the lowest settlement rate of 0.09% (n=9).

SEAFDEC/AQD's
abalone hatchery
stock has the highest
fecundity producing
more than
1 million eggs

To improve abalone veliger survival rate, techniques in harvesting and incubation were refined. Incubation of trochophore larvae at 26°C for 24 hours using a flow-through system resulted to higher survival rates.

Moreover, molecular characterization of potential oyster broodstock from wild sources is currently being done by the University of the Philippines in the Visayas as part of the National Oyster R&D Program led by SEAFDEC/AQD with funding support from DOST.

Finally, under the newly approved DOST-funded study on mud crab selective breeding, tissue samples from mud crab broodstock sourced



Oyster hatchery set-up at SEAFDEC/AQD

from Camarines Sur, Northern Samar and Surigao were analyzed for primer screening and development in Japan. Three new potential msDNA markers were identified. These new msDNA markers will be used in addition to the three working msDNA markers based on published literature.

Apart from genetic intervention, nutritional methods to improve reproductive performance in farmed aquatic commodities have been conducted. The sustainable production of polychaetes (*Marphysa mossambica*) was pursued as these serve as potential feed for mud crab *Scylla serrata* broodstock. Various feed combinations of live polychaetes and polychaete meal as food for mud crab broodstock have been evaluated to improve reproductive performance and larval quality. Zoa 1 production per spawning of crab fed with natural food (NF: mussel, fish, and squid at daily rotation) and live *Marphysa* (NFM) was higher (1,251,242 ± 709,582) than those that were not fed live polychaetes (NFnoM, 416,588 ± 435,834). Increasing the level of *Marphysa* meal in formulated diet in combination with NF without live polychaetes correspondingly increased zoa 1 production (NFnoM + 20 MFD;

Feed combination
of natural food and
live polychaetes
improved reproductive
performance of
mud crab

573,211 ± 294,609 > NFnoM + 10MFD; 491,150 ± 531,274 > NFnoM; 416,588 ± 435,834).

Oyster gonadal
development is faster
when reared in estuaries
and semi-intensively
managed ponds than
in tanks

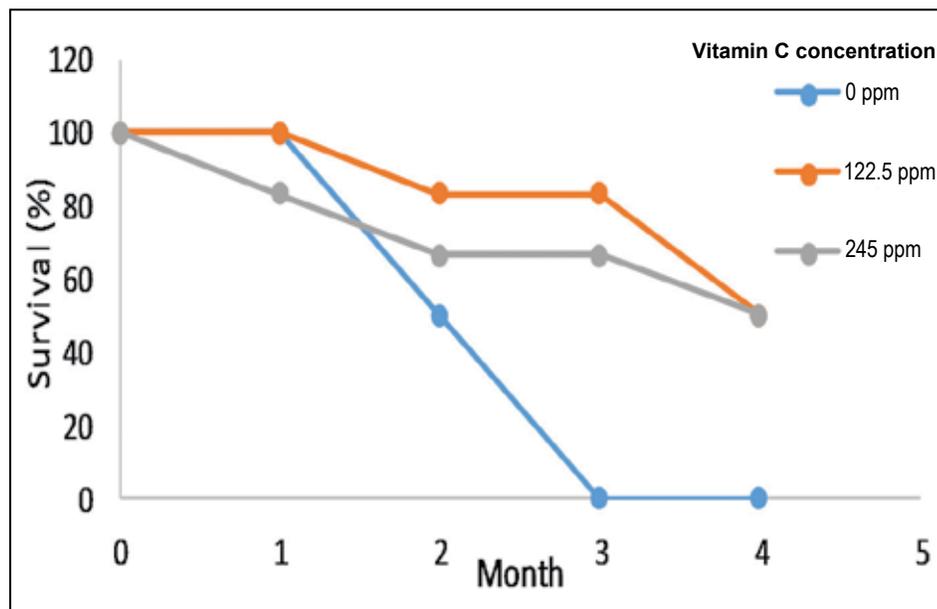
Protocols for broodstock management and conditioning are also being developed for oyster *Crassostrea iredalei* to maximize production. Faster gonadal development was observed in oysters stocked and reared to maturity in the estuary and in semi-intensively managed ponds than in tanks. Sexual maturity and histological index were high after 15 days of conditioning (DOC) where 90% of estuary-reared and 80% of the pond-reared broodstock were noted to be sexually mature having histological gonad indices (GI) of 490 and 480, respectively. Finally, when trials on the effect of salinity on gonadal maturation were conducted, at day 15, oysters reared in 20 ppt were observed to be 60% and 40% in late active and ripe stages, respectively. On the other hand, oysters reared in 25 ppt were noted to be 10% ripe and 70% in the late active stages; while those reared in 30 ppt were 25% ripe and 70% in the late active stages.

Tiger shrimp *Penaeus monodon* broodstock diets have been tested with the aim of improving broodstock reproductive efficiency. Captive shrimp breeders (1 male:1 female and a density of

Captive tiger shrimp
broodstock achieved
50%
survival when fed diets
with Vitamin C

six individuals per tank) were stocked in 12-ton tanks. Females were unilaterally ablated. Stocks were fed a combination of squid, mussel, and pelleted diets. Treatment diets contained 0, 122.5, or 245 ppm Vitamin C. There was only one replicate per treatment due to the lack of captive broodstock. Results showed that none of the broodstock fed with the control diet (no Vitamin C) survived until the termination of the test. For both 122.5 and 245 ppm Vitamin C level treatments, survival was 50%. Survival results obtained in this test further support the observations during the previous project where mortalities experienced during domestication ceased when Vitamin C was incorporated in the diet. Maturations and spawnings were observed in all treatments. However, none of the eggs hatched. A total of three females matured in the treatment using the higher 245 ppm level of Vitamin C. However, only one of these spawned. Compared to the control, a higher number of eggs were produced (96,000 eggs), but none of these hatched. For the other two maturations, the ovaries regressed and no spawning occurred.

Meanwhile, a single batch of nauplii was produced when F₃ females were stocked with F₂ males. The nauplii were grown to postlarval stage in the hatchery and to broodstock size in ponds. Half of the stocks have been transported to Igang, Guimaras where the pens have been constructed. Six pens have been stocked with *P. monodon* subadults. The stocks in the pens have attained 60-80 g BW, while 50-70 g BW have been attained in the ponds. Captive broodstock from the ponds have been transferred to the tanks and have been conditioned for three weeks to the respective experimental diets. The stocks in the pens have also been conditioned to the feeds. Females in both pens and tanks have just been ablated. Monitoring for maturation has started for both holding systems.



Survival of *Penaeus monodon* broodstock during the Vitamin C incorporation experiment



PHOTOS BY FAYA

Representative colors of wild female silver therapon gonadal tissue

Emerging species for aquaculture

Recently, SEAFDEC/AQD started a study on the nutritional evaluation of wild-sourced and hatchery-bred stocks of silver therapon for feed development. One of the aims is to compare the growth and reproductive performance as well as the nutritional composition of wild and hatchery-reared silver therapon *Leiopotherapon plumbeus*. Silver therapon which comprised the wild

stock were collected from a fish trap in the lake near the research station while the hatchery stock were from the fish maintained in cages suspended in outdoor tanks at SEAFDEC/AQD's Binangonan Freshwater Station. From July to November 2015, a total of 120 wild specimens were collected, 85 of which were females (SL: 71.94 ± 10.72 mm) and 35 were males (SL: 75.79 ± 10.80 mm) or a female:male ratio of 2.43:1. Mean female GSIs (%) progressively

declined from July (4.74%) until November (1.69%). Mean GSIs (%) of male silver therapon decreased from July to September (4.43 to 1.55%), increased in October (2.20%) and then declined in November (2.13%). Mean GSI (%) of female silver therapon increased from July (1.29%), to peak in September (4.78%) and declined thereafter. Mean GSI (%) of male silver therapon was low in July (1.38%), but increased in August (4.43%) and then declined thereafter.

Out of the 70 hatchery-bred stocks sampled, 42 were females (SL: 98.21 ± 16.93 mm) and 28 were males (SL: 83.00 ± 13.29 mm), or a female: male ratio of 1.5. Mean female GSIs were typically high (8.22 to 13.43%) from July to September, and declined to levels similar in July (8.57%). Mean male GSIs (%) increased from 5.8% in July to 11.01% in September, and declined to 7.56% in November. Mean GSIs (%) both progressively increased for female (3.08-6.29%) and male (2.00-8.57) from July to November.

Tank trials were conducted to compare growth and reproductive development of wild-sourced (2.47 ± 0.44 g in body weight; BW) and hatchery-bred (2.50 ± 0.23 g BW) *L. plumbeus* juveniles stocked at a density of 30 pcs m⁻³ and reared in four replicate cages (1.0 x 1.0 x 1.5 m depth) suspended in tanks. After 8 weeks of rearing, fed wild and hatchery-bred stocks have grown to 5.07 ± 0.51 g and 5.58 ± 0.98 g BW, respectively. Whereas, unfed wild and hatchery-bred stocks had body weights of 3.32 ± 0.47 g and 2.99 ± 0.50 g, respectively. Survival rates were higher for the fed hatchery-bred stocks ($97.5 \pm 1.67\%$) than their wild conspecifics ($91.7 \pm 10.4\%$) during grow-out culture.

Species for stock management and enhancement

Activities are being undertaken to study the giant grouper for purposes of broodstock development and genetic stock management. ACIAR is supporting preliminary work on broodstock collection and genetic variability assessment using molecular markers.



PHOTO COURTESY OF SMB URSUA

Extraction and purification of DNA samples from seahorse

As for the seahorse, *Hippocampus* sp., tissue samples were collected from the study site (Molocaboc Island, Sagay City), SEAFDEC seahorse hatchery and seahorse hatchery in Japan. Genetic characterization of collected seahorses was done. Only one species, *H. comes*, was noted to be present in Molocaboc Island. Sequencing of mtDNA cytb and 16s rRNA genes were conducted in all six species of seahorses and a pipefish and phylogenetic trees were constructed to show the relationship among seahorse species. Primers HiSpiF1 and HiBarF1 were confirmed useful for the species identification of *H. spinosissimus* and *H. barbouri*. The expected band size in HiSpiF1 is 235 bp, while for HiBarF1, the band size is noted to be 464 bp. For *H. comes*, a microsatellite enrichment library was constructed and 35 primer pairs (reverse and forward) were designed to amplify potential microsatellite markers. After PCR standardization, electrophoresis and visualization in agarose gels, 19 primer pairs were selected for further screening by fragment analysis using polyacrylamide gel electrophoresis (PAGE). Microsatellite marker analysis showed very low degree of differentiation among populations ($F_{st}=0.086$) of wild and hatchery produced seahorses. Primers of *H. comes* microsatellite loci were successfully cross-amplified in other species of seahorses and a pipefish. Apart from environmental manipulation,

nutritional approaches are being applied to improve reproductive performance in the sandfish *Holothuria scabra* broodstock. Survival of the broodstock fed the shrimp feed and *Sargassum* powder was 100% when reared for the entire 8-week experimental run. The *Navicula*-fed group had 100% survival until the 7th week but only 80% survived until the end of the 8th week. When warm shock versus cold shock was used in artificial spawning, the percentage of broodstock that spawned was 7% for those exposed to warm shock whereas it was 2% for those under the cold shock treatment.

Blue swimming crab production is totally reliant on wild stocks. Hence it is important to first consider how one can effectively transport potential spawners from the wild to the farm to be used for seed stock production either for aquaculture or stock enhancement/management. A study tried to determine a suitable protocol for the transport of blue swimming crab broodstock. Results showed that survival rates of *Portunus pelagicus* subjected to various loading densities and duration in a simulated transport set up did not differ significantly ($P > 0.05$) immediately after transport and 48 hours post transport suggesting that it is still feasible to transport crabs at a high loading density (10 pieces) for six hours transport period.

Refine hatchery and nursery management methods to improve seedstock quality and production

Commercial aquaculture species

Abalone hatchery production has been improved with the use of microparticulate diets as alternative feed. An agar-bound microparticulate diet has been formulated based on the nutrient profile of post larval abalone. Proximate analysis of the composition of the microparticulate diet (MPD) showed higher levels of crude protein at 47.2% and lipid at 8.9% compared to 14.9% crude protein and 2.1% lipid for the diatoms (*Navicula* sp). When fed a combination of natural food and microparticulate diet for 90 days, mean shell length was highest for hatchery-bred stocks (21.95 mm). This was slightly higher than those of the wild stocks (20.72 mm) given the same feeding treatment. Mean percent survival was also highest for the hatchery and wild stocks fed a combination of natural food and MPD, ranging from 38.6% to 43.3% regardless of feeding duration.

Nitzschia sp., a diatom, induces high abalone settlement and survival rate

Another study on abalone focused to increase abalone juvenile production through the improvement of hatchery culture techniques. The efficiency of using chemical cues (positive ions, algal extracts) to improve settlement rate was evaluated. Settlement inducers such as magnesium chloride hexahydrate and dopamine hydrochloride were tried and it was noted that use of dopamine hydrochloride at 10^{-6} M resulted in higher settlement rate of 32.67-37.33% than the control (22-32%). Meanwhile, magnesium chloride hexahydrate had no settlement inducing effect at all concentrations that were tested. The local diatom isolate, *Nitzschia* sp. was noted to consistently induce high abalone settlement and survival rate. Settlement rate after 10 days ranged from 4.20-



PHOTO BY J. LADJIA

Empty oyster shell is a suitable settlement substrate for oyster spat

4.77% while post-settlement survival (90 days) was 52.91%. A second verification run in 2-ton concrete tanks consistently showed that *Nitzschia* sp. improved settlement rate after 10 days of rearing (4.01-4.64%). Post-settlement survival was 50.95%.

An experiment was conducted to develop an efficient sorting and harvesting protocol and this involved the use of anesthetic agents as muscle relaxant for abalone juveniles. The dose of 1 ppt (1.0 ml/L) 2-phenoxyethanol resulted in shortest detachment time of 6 minutes in 2.6-3 cm juveniles but shortest recovery time of 3.8 minutes was observed at 0.25 ppt. Benzocaine showed comparable detachment time of 13.05-14.98 in three concentrations (100, 150, and 200 ppm), but a shorter recovery time of 20 minutes was observed at 150 ppm. As for larger juveniles (5-6 cm), 2-phenoxyethanol gave the shortest detachment time of 4.7 minutes in 1 ppt concentration and the shortest recovery time of 6.1 minutes at 0.5 ppt concentration.

The combined spawning methods of dessication with flow-through UV-irradiated water, were used in the

production of quality oyster seedstock. It was observed that mixing milt from one male with 0.5–4 M eggs resulted in 100% fertilization; however, hatching rate (HR) was higher (39–48.5%) when sperm solution was mixed with 0.75–2 M eggs. The most suitable substrate for settlement were empty oyster shells (OS) with settlement of 0.95 spat/cm², then marble stones (MS) and polyethylene strips (PES) with settlement of 0.78 spat/cm² and 0.23 spat/cm², respectively. Spats can be detached more easily from PES than from OS and MS. To improve spat production, treatment of epinephrine bitartrate (EPI) was tried apart from the use of downwelling vs. upwelling settlement units. EPI-treated pediveligers had resulted in 100% settlement rate (SR) and survival rate (S) of $64.7 \pm 19\%$ but was not different from the control; use of downwelling systems resulted in 95-98% individual spats. Methods of remote setting of oysters were tried and results showed that survival of pediveligers transported with water was higher ($77\% \pm 1\%$) than those transported without water ($61 \pm 8\%$). Settlement rate was $28 \pm 6\%$ for those transported with water and $16 \pm 6\%$ without water.

Efforts have been made to further improve mud crab hatchery schemes. The larval performance of mud crab *Scylla serrata* fed three types of SEAFDEC/AQD larval diet with varying protein sources (squid, annelids, and squid + annelids) in combination with natural food (*Brachionus* and *Artemia*) were compared. All the three diets contain the same ingredients except for the percentage level of squid and annelid; Diet A (2% squid meal or SM), Diet B (2% polychaete meal or PM), Diet C (1% SM and 1% PM) plus a control diet composed mainly of natural food, showed survival of larvae was comparable in all the treatments. Growth index was highest in larvae fed natural food alone compared to those larvae fed any of the formulated diet. The physical property of the SEAFDEC/AQD formulated diet needs further improvement.

Another type of intervention to help increase hatchery/nursery production of mud crabs was the use of shelters. A study looked at the ideal number of shelters and stocking density that can improve crablet yield. The number of shelters (4, 8, 12 units, covering 1, 2 and 3 m² of the base of the cage) used per 12 m² net cage was tested using 3 different stocking densities (30, 50, and 100 ind/m²). This was done to determine if stocking density can be increased without resulting in lower survival through increasing the surface area available for hiding of the crablets especially during molting. In the nursery Phase 1, use of 4, 8, or 12 ribbon net shelters revealed that survival significantly decreased as stocking density increased. The number of shelters did not significantly affect survival. Mean percent survival were 55.66 ± 1.70%, 67.56 ± 1.54%, and 79.05 ± 2.52% at 100, 50, and 30 ind/m², respectively. Results of the first run showed that survival at each stocking density significantly differed from the others, but not the number of shelters. Size of crabs did not significantly differ among treatments due to the variability in data. However, the percentage of medium-sized crablets



A berried blue swimming crab

PHOTO BY JJ HUERVANA

significantly decreased as the stocking density increases regardless of the number of shelters used. Similar results were obtained in Phase 2.

Finally, to determine whether sorting at different weeks could improve survival, stocks were sorted into 2-3 size classifications (small, medium, large) at different weeks; for example, 1, 2, and 3 weeks (no sorting within the whole Phase 1 rearing) and at two stocking densities (600/cage or 5 ind/m², and 1,200 or 10 ind/m²) during the Phase 1 nursery. Results showed that survival in those cages that were sorted every week was significantly lower than the other treatments. Sorting at two weeks did not significantly improve survival.

Apart from mud crab, larval culture studies have been done on the blue swimming crab (BSC) *Portunus pelagicus*. BSC larvae were fed natural food and commercially available shrimp formulated diets (BP Nippai, *P. japonicus* and *P. monodon*) in combination with natural food to reduce the use of natural food that requires more labor and facilities. Results showed no significant differences in the survival and growth among the treatments.

Criterion for the determination of the quality of newly hatched zoeae for stocking in the hatchery was developed. Newly hatched zoeae from different females were tested for stress tolerance

using different formalin concentrations of 0, 80, 120, and 140 ppm at 0.5, 1, 2, 3, 4, 5, 6 and 24 h duration. All the zoeae used for the formalin stress were also utilized for the production runs to validate the results. The percent cumulative larval mortality increased as the formalin concentration increased. Table 1 summarizes the median lethal concentrations of formalin in newly hatched BSC larvae at various durations. Initial results showed that formalin stress test may be used to determine the quality of the newly hatched zoeae for seed production. Additional runs will

Table 1. Median lethal formalin concentrations in newly-hatched *Portunus pelagicus* larvae at various durations

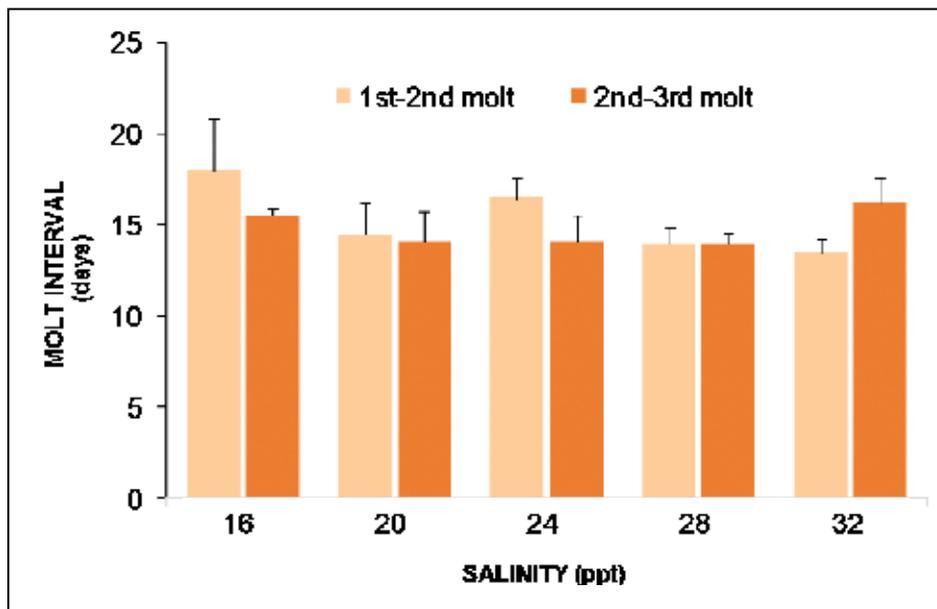
Time (h)	LC50 (mgL ⁻¹)	Confidence interval (mgL ⁻¹)
0.5	123.01	112.48-134.72
1	110.99	101.15-113.81
2	111.70	102.83-121.49
3	103.57	93.27-115.14
4	99.20	88.72-111.03
5	94.24	83.16-106.96
6	93.07	83.48-103.84
24	69.97	55.48-108.88

still be conducted to confirm the results. The determination of larval quality is important so that only good batches will be used for further larval rearing.

The use of antibiotics during larval rearing showed that BSC megalopae can be produced even without the use of antibiotics if larval quality is good. Stress test using formalin is utilized to determine the larval quality. The application of antimicrobials to control bacterial population in BSC larval culture is until megalopa stage only. Although the use is short term, it may lead to the development of resistant strains of bacteria. Hence, other alternatives for antibiotics in BSC hatchery operations will be tried.

An experiment to test the salinity requirement of blue swimming crab later instar stages was conducted. A comparison of molt intervals among test salinities of 16, 20, 28 and 32 ppt showed that the number of days between molts (from first to second then second to third molts) were similar in all treatments.

The most suitable feeding regime for BSC nursery was evaluated. Crab instars were fed formulated test diets in combination with mussel at a ratio of 70% formulated diet and 30% mussel meat. After 45 days, percentage survival ranged from 22 to 38%, and values were not significantly different. A confirmatory run was conducted to validate the results. To reduce incidence of cannibalism, crab instars were stocked individually in perforated plastic containers. Low survival rates were still obtained since plastic containers had to be lifted out of water during feeding, and further stressed the animals. Thus, the next run will be conducted in cages installed in ponds. To further refine methods for nursery rearing of BSC, trials to identify the most suitable substrate and shelter were done. After three weeks of nursery rearing (Phase 1), crab instars which were initially stocked at 600 ind/m² exhibited significantly higher survival with net curtains and framed nets. Framed ribbon and curtain nets gave significantly higher survival than pipe shelters or the control. In Phase 2, all shelters resulted in survival rates that were not significantly different from each other.



Intervals between first and second, and second and third molts of *Portunus pelagicus* juveniles reared at different salinities



PHOTO BY MR. LUHAN

Planting of *Kappaphycus* in longlines

To enable the promotion of *Kappaphycus* culture, nursery rearing techniques are being refined. Tissue cultured cultivars are produced in the laboratory and reared in the land-based nursery tanks and in sea cages. The protocol in the land and sea-based nurseries is continuously being optimized to shorten the culture *in vitro* and *ex vitro*. Meanwhile, tissue culture ex-plants were successfully outplanted in

Bohol, Zamboanga, and Guimaras. Good growth of the propagules was observed until the fourth pruning stage only.

Emerging species for aquaculture

Silver therapon *Leiopotherapon plumbeus* is a promising species for commercial inland aquaculture particularly because it is an indigenous species and it commands

a good market price. This year, two rotifer strains (*Brachionus rotundiformis* and *B. plicatilis*) were tested as starter food for first feeding larvae. *B. rotundiformis* is a suitable starter food for first feeding silver therapon larvae; recommended feeding protocol as follows: *B. rotundiformis* from 2 to 13 days after hatching (DAH), *Artemia* nauplii from 14 to 35 DAH, and co-feeding of *Artemia* nauplii and artificial diet from 36 to 95 DAH. Another aspect of silver therapon larviculture that was studied was on the ideal stocking density for growth and survival. It was noted that larvae attained best growth (19.7 mm total length; 126.3 mg wet weight) and highest survival

(81.4%) at 5 L⁻¹ after 35 days of rearing (from 7 DAH with an initial total length of 6.9 mm and wet weight of 0.497 mg). A microparticulate diet was also tried on silver perch larvae and preliminary results showed that weaning time did not have a significant effect on final length (18.1-19.5 mm) and body weight (94-104 mg) of *L. plumbeus* larvae, which were comparable to that of the control group (21.2 mm TL; 102 mg) where no weaning was made onto microparticulate diet.

Improvements in the hatchery and nursery production of sandfish *Holothuria scabra* have been undertaken. Refinements in the hatchery protocol include the use of

appropriate food and stocking densities. It was noted that *Chaetoceros*-fed larvae had better survival, faster development and less deformities. Larval development is better in the group fed 20,000 cells/ml algal concentration while an increase in the percentage doliolaria was faster and higher in the 20,000 cells/ml feeding.

Species for stock enhancement

The seahorses, *Hippocampus barbouri* and *H. comes* are continuously being propagated in the SEAFDEC/AQD hatchery for possible stock release.

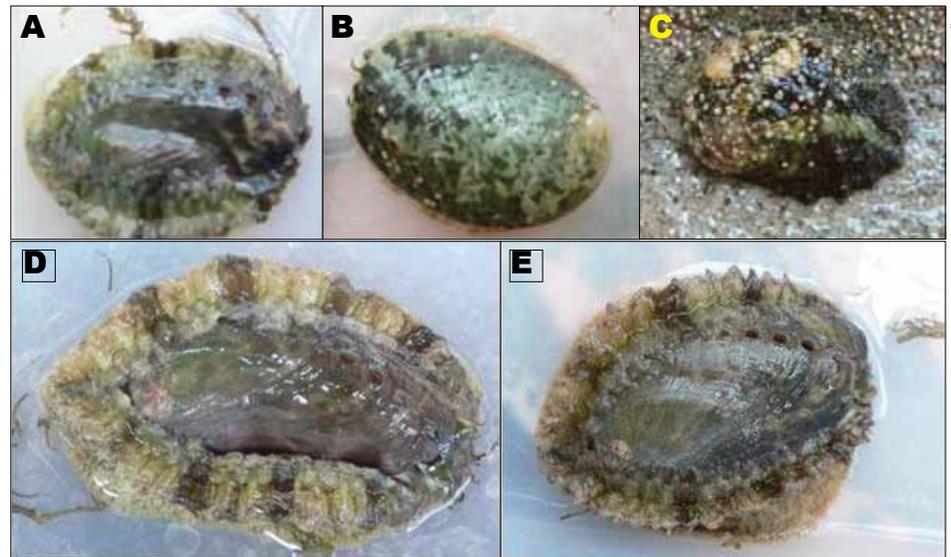
Develop schemes for the production, management, maintenance and dissemination of genetically selected and improved stocks

Commercial species

Selective breeding programs have continued for selected commodities (milkfish, mud crab, shrimp and abalone) with support from SEAFDEC/AQD and the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) of the Department of Science and Technology.

For mud crab, a study on the selective breeding was newly approved, which aims to develop a disease resistant and a fast growing strain. Collection of breeders from Camarines Norte and Surigao del Norte to build the base population for selective breeding has already been initiated. Screening of crabs for diseases (WSSV and IHNV) was done. Six and two females from Camarines Norte and Surigao populations, respectively, have already produced crablets which were used for growth and challenge test for the evaluation of disease resistance.

For milkfish, with the outcome of the molecular marker studies, plans for comparing growth in stocks known to potentially have high genetic variability and/or fitness shall be evaluated and reared through field trials in ponds. Plans



PHOTOS BY M DELA PEÑA

The Philippine abalone species *Haliotis asinina* (A), *H. glabra* (B), *H. planata* (C). Abalone hybrids produced from male *H. glabra* (D) and from male *H. planata* (E). Female parent of both hybrids is *H. asinina*

to look for markers for sex determination and tolerance to environmental stressors are to be undertaken as well.

Hybridization is being continuously implemented using the local commercial abalone species *Haliotis asinina*. This

species has been crossed with other Philippine abalone species, *H. planata* and *H. glabra*, to enable the production of stocks/species with improved traits. Some of the findings of this research reported that pure *H. asinina* and hybrid *H. glabra* attained optimum growth

(*H. asinina* - 38.6 g; hybrid *H. glabra* - 36.0 g) after 420 days of culture (DOC). On the other hand, hybrid *H. planata* attained optimum growth (44.16 g) at 450 DOC, but it is heavier than the other two abalone species. The hybrids are being on-grown to become potential broodstock. However, the gonads of the potential breeders did not develop beyond stage 1 and stage 2. All have been tagged (750 pieces) and were returned to the Igang Marine Station (IMS) for reconditioning. All of the hybrids including that of *H. varia* are being maintained at IMS. Some samples of the hybrid stocks were sent to Prof. Arai of Hokkaido University for genetic characterization.

As for the triploidy experiment, based on metaphase spreads, a higher number of chromosomes is found in 9 and 10 mM caffeine-treated larvae which is possibly 3 N.

Fertilized *Kappaphycus* is less susceptible to ice-ice disease

For seaweeds, ice-ice disease is a major problem. Methods to develop resistant strains of the seaweed *Kappaphycus* and reduce epiphytes were being studied. Haploids, diploids and tissue cultured

seaweeds are planted in lines and were installed inside a net cage. Occurrence of ice-ice was monitored by counting the bundles with ice-ice and divided by the total number of bundles multiplied by 100 per line. Fertilized *Kappaphycus* have been found to be less susceptible to ice-ice. Diploid *Kappaphycus* have higher specific growth rate than haploids and the carrageenan quality from both diploids and haploids are not different. Carrageenan viscosity of the diploid is significantly higher than that of the haploid. Finally the carrageenan quality of haploid and diploid *Kappaphycus* or those produced from spores is not different.

Adopt economically viable systems to produce sufficient seedstock

Several fish/shellfish production projects are being implemented at SEAFDEC/AQD to demonstrate the viability of small-scale and/or large-scale seed production systems. Mass production of sex-reversed and mixed-sex Nile/red tilapia fingerlings as well as large-scale production of abalone juveniles, are continuously being done.

In the small-scale Nile tilapia hatchery, about 200,000 Nile tilapia and 7,900 red tilapia swim-up fry were produced. Catfish are also being produced in the same hatchery.

For the abalone, juvenile production is on-going. A total of 41,370 abalone juveniles (5 mm-8 mm shell length) have been produced with an average survival rate of 1.23% and then reared further until 1.1-1.5 cm in size. A total of 12,500 juveniles (1.1-3.0 cm) were sold.

The verification trials on reverse day-night cycle and the use of *Nitzschia* sp. as diatom diet were conducted to further improve abalone juvenile production. Initial large-scale production of abalone juveniles was done using *Nitzschia* sp. as diatom feed in 12-ton outdoor tank

stocked with 1,500,000 veliger larvae. Using this set-up, the survival rate of abalone juvenile (5 mm-8 mm shell length) was 0.20% yielding 3,033 abalone juveniles. Another trial was done using two 3-ton tanks stocked with 300,000 veliger larvae and it resulted to an average of 1.33% survival rate yielding a total of 7,960 abalone juveniles.

Capacity-building of fish farmers and other industry stakeholders on appropriate breeding and larval rearing technologies

As part of the capacity building component of the three projects under the *Refinement of Mud Crab Hatchery Technology Program* supported by PCAARRD-DOST; private sector, LGU and SUC collaborators, and other stakeholders underwent training at SEAFDEC/AQD either as participants in a regular training course, on-the-job training or customized training

scheme. Moreover, technical assistance was provided in the hatchery site of the collaborators. Up to 3% survival rate from zoea to megalopa in large tanks was obtained in the hatchery operation of the collaborators. As for the pilot demonstration project, the construction of the mud crab hatchery in Guindulman, Bohol was completed and turned over to the local government of Guindulman on

May 2015. The technical staff assigned in the Guindulman hatchery underwent training at SEAFDEC/AQD while the hatchery construction was ongoing. Two runs were conducted in the hatchery with technical assistance provided by SEAFDEC/AQD staff. Survival rates of 1.0 and 3.0% from zoea to crab instar were obtained in the first and second runs, respectively.

Capacity building for nursery operation was also provided to private sectors and SUCs. The following are the identified collaborators for the mud crab nursery: (a) Aklan State University-New Washington Campus; (b) Zamboanga State College of Marine Science and Technology; (c) Ms. Gretchen Montelibano-Torno (Negros Occidental); (d) Engr. Raymund Morales; and (e) Golden Reed Seafarms (Negros Occidental). Mr. Rey Acap of Iloilo has been assisted as well in the conduct of mud crab nursery runs in large nursery tanks within his hatchery. Two other pond owners have been identified as collaborators. These two collaborators started the runs at the end of August.

Crab reared
in nursery tanks has a
survival rate of up to
90%

Survival rates of up to 90% were achieved for both phases of the nursery culture in Mr. Acap's facilities. This run will give an insight on the feasibility of using idle tanks for nursery rearing. Two other pond owners, Ms. Jane Alimpuyo whose pond is in Belison, Antique and Mr. Lorenzo Pangilinan in President Roxas, Capiz have expressed interest on being collaborators for the nursery. Runs have been made in their ponds, and both were able to obtain more than 50% survival in the nursery.

For the blue-swimming crab, capacity building started with the training of technical assistants working for the Philippine Association of Crab Producers Inc. (PACPI). They underwent training on the seed production of blue swimming crab at the SEAFDEC/AQD Crustacean Hatchery. PACPI used to operate a blue swimming crab hatchery in Buyu-an, Tigbauan near SEAFDEC/AQD. The crabs produced from their hatchery were used for stock enhancement in Iloilo. The first batch of juvenile blue swimming crabs were released in Ajuy and Carles while the second batch was released in



PHOTOS BY ET QUINITIO

The hatchery constructed through the supervision of SEAFDEC/AQD with funding from DOST-PCAARRD was turned over to the municipality of Guindulman, Bohol on May 2015



A mud crab hatchery in Oton, Iloilo being assisted by SEAFDEC/AQD under the DOST-funded project

marine sanctuaries of Anilao, Banate and Estancia. Two collaborators (private sector and SUC) have been identified to adopt the technology.

Training activities on abalone hatchery production were conducted from January 2015 to August 2015 with on-the-job trainees from schools such as Bohol Island State University, Cebu Technological University, Central Philippine University, Mindanao State University-Maguindanao, Northern Negros State College of Science and Technology and St. Paul University-Iloilo.

Several specialized training courses were offered to local government representatives, private sector investors and fisherfolk. These were on sandfish, abalone, tilapia and giant freshwater prawn. Apart from these customized courses, on-the job trainees were also accommodated in the AQD hatcheries during this period. Moreover, technical assistance is continuously being offered to local and/or international private sector clients through the *ABOT (Agree-Build-Operate-Transfer) AquaNegosyo* Program.

Promoting Healthy and Wholesome Aquaculture (HWA)

PHOTO BY DEVCOM



Snapper harvest at SEAFDEC/AQD's Dumangas Brackishwater Station

RATIONALE

The Healthy and Wholesome Aquaculture program aims to attain sustainable aquaculture production through provision of healthy and well-balanced diet for every fish species, taking into consideration the practice of best management and good aquaculture practices. Previous research and development efforts on these aspects have already resulted in the phenomenal growth of the sector in the last decades. However, further studies are necessary due to the current problems posed by ecological, economic, and climatic changes. In response to these challenges, the HWA program involved studies on innovations in nutrition & feed development and fish health management as well as preservation of environmental integrity of aquaculture sites in order to achieve a sustainable aquaculture production.

Sustain aquaculture production through innovations in nutrition & feed development and fish health management as well as preservation of environmental integrity of aquaculture sites

OBJECTIVES

1. Find alternative feed ingredients for fish meal and fish oil and develop effective feeding strategies that incorporate sound environmental management
2. Develop feed for specific growth stages of fish species for which no artificial feed has been formulated
3. Promote efficient feeding practices and provide adequate nutrition for better appreciation of the concept of feed conversion ratio among fish farmers
4. Investigate the efficacy of probiotics and rationalize the need and application of diagnostics that will ensure biosecurity within the culture systems and keep out exotic pathogens, especially transboundary pathogens
5. Promote the wider use of conventional diagnostic as well as new methods especially for newly reported, emerging diseases
6. Find effective alternative safe drugs/chemicals (including natural products) to manage aquaculture diseases in lieu of harmful chemicals and drugs which have been regulated or banned due to quality and safety issues

Find fish meal and fish oil substitutes and develop effective feeding strategies that incorporate sound environmental management

The aquaculture feed industry is experiencing a pressing need for suitable fish meal and fish oil substitutes. It cannot continue its dependence on fish meal and fish oil which are finite resources and may cause the demand for these ingredients to exceed the global fish meal and fish oil supply. The situation becomes worse since the price of aquaculture products has either decreased or stagnated. To address this issue, several alternative feed ingredients that can be used as substitutes for fish meal and fish oil have been tested in various fish species. Some of the ingredients identified are: (1) 40% fermented cowpea to replace fish meal in milkfish diet; (2) 50% fish meal replacement with defatted soybean meal and 40% soy protein concentrate in milkfish diet; (3) 45% replacement of soybean meal with DDGS in milkfish diet; (4) 10-15% inclusion of milkfish hydrolysate in grouper diet; and (5)

fertilized *Ulva pertusa* as fish meal substitute for abalone juvenile feed. The use of these locally available alternative protein sources in the diets of various fish species may offer opportunities to reduce feed cost and decrease environmental degradation.



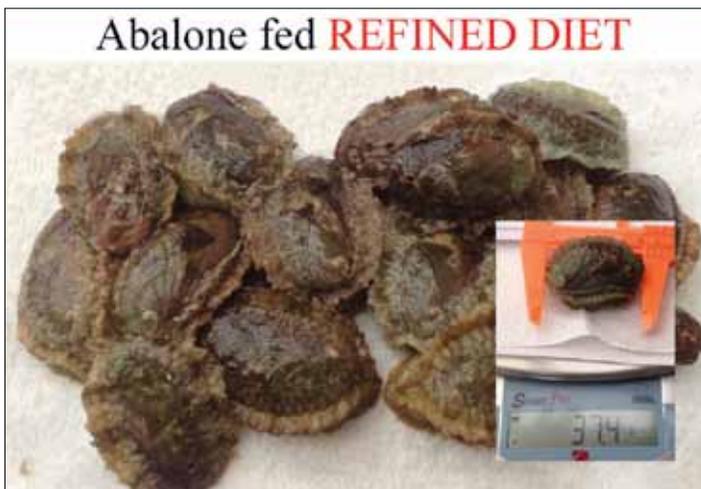
PHOTO BY M TERUEL

Fertilized *Ulva pertusa*, a potential alternative protein source for abalone juvenile feed

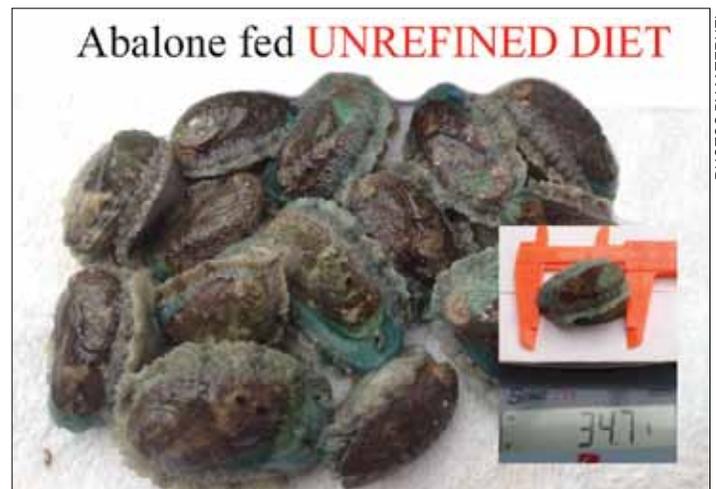
Effective feed management strategies were also developed that include: (1) low feeding rates and skip feeding for freshwater prawn; (2) use of marine-based and purified attractants such as *Acetes*, squid meal, shrimp paste, putrescine, cadaverine; and (3) application of

different feed shapes such as spherical, cube, and tubular for the mud crab diet which resulted in effective handling of crab claws and eventually resulted in higher feed consumption.

Develop feed for different growth stages



Abalone fed refined diet with brownish color (Inset: SL = 54 mm, BW = 37.4 g)



Abalone fed unrefined diet with bluish bands (Inset: SL = 41 mm, BW = 34.7 g)

PHOTOS BY M TERUEL

Currently, a very limited number of commercial feeds have been developed for some species at specific growth stages, which significantly affect feed efficacy when used with other species or stages. Specific formulations for each species at different stages should

be identified. To address this need, SEAFDEC/AQD established basal data on protein and amino acid requirements for the development of an effective diet for pompano. Moreover, a refined diet formulation with higher water stability and digestibility for abalone grow-out

culture was tested in concrete land-based tanks. Lastly, a study on the quantitative amino acid (leucine and isoleucine) requirements for the juvenile Asian sea bass has started, which will be used as a guide in diet formulation for a cost-effective feed for this species.

Promote efficient feeding practices and provide adequate nutrition for better appreciation of the concept of feed conversion ratio among fish farmers

In some rural aquaculture, efficient feeding practices are not commonly practiced by fish farmers. Thus, SEAFDEC/AQD conducted several studies that would promote better understanding of the importance of feed conversion ratio (FCR) and application of adequate nutrition that is beneficial in keeping aquaculture species healthy.

One of the studies conducted improved the growth performance of *Gracilariopsis heteroclada* by using short-term nitrogen enriched plant materials. The application of the new enrichment method in pond culture of *G. heteroclada* resulted in high growth rates during dry months (4.32 to 5.82% day⁻¹). The method also minimized the proliferation of epiphytes.

Another study compared the reproductive performance of captive and wild *Penaeus indicus* broodstock. Results showed that there was no significant difference in the fecundity and hatching rate of eggs produced from wild and captive broodstock. However, percentages of spawning and rematuration of wild broodstock were significantly higher compared with captive broodstock. A 60-day tank experiment showed that postlarvae (PL) produced from captive broodstock had significantly higher survival compared with PL produced from wild broodstock. Significant difference was not detected when growth and FCR were compared. Pond culture of hatchery-bred *P. indicus* for 90 days is more economical compared with the shorter 60-day culture.

Another study focused on the use of SEAFDEC/AQD diet in brackishwater pond, which has been demonstrated in the semi-intensive grow-out culture of groupers, *Epinephelus coioides* and *E. fuscoguttatus*. On the other hand, semi-intensive farming of rabbitfish in brackishwater ponds used formulated diet with lower FCR values compared with that of the commercial feed. Verification



Weekly harvest of pond cultured *Gracilariopsis heteroclada* at SEAFDEC/AQD's Dumangas Brackishwater Station (right) and at Brgy. Nabitasan, Leganes, Iloilo (left)

PHOTOS BY SS AVANCEÑA



Pond cultured *Penaeus indicus* using post-larvae produced from captive broodstock

on the use of immunostimulant-containing diets for the Nile tilapia in low volume, high density cages was also done in Taal Lake, Batangas.

Strategies to reduce cannibalism in mud crab nursery were also identified. The use of net shelters called frame ribbon nets

was found to be the most suitable strategy to reduce cannibalism resulting in 60-70% survival at a density of 50 ind/m².

Transfer of technology package was also done through e-learning (AquaNutrition On-Line) with funding support from the Government of Japan.

Investigate the efficacy of probiotics and rationalize the need and application of diagnostics to ensure biosecurity in culture systems

An indigenous poly- β -hydroxybutyrate (PHB)-accumulating mixed bacterial culture and two PHB-accumulating *Bacillus* spp. designated as JL47 and JL1, respectively, were isolated from a Philippine shrimp culture pond and investigated for their capacity to improve growth, survival and robustness of *Penaeus monodon* postlarvae (PL). PHB-containing bacterial cultures were incorporated in the feed and given to shrimp PL1 and shrimp PL30 for 30 days and thereafter respectively challenged with *Vibrio campbellii* and exposed to a lethal dose of ammonia. Notably, growth and survival were higher for shrimps receiving a diet with PHB-accumulating bacteria compared with shrimp receiving diet without bacterial additions before the bacterial challenge and ammonia exposure. Moreover, shrimp fed PHB-accumulating bacteria showed a higher survival compared with non-treated shrimp after the bacterial challenge suggesting an increase in robustness for the shrimp.

Shrimp fed diet with PHB-accumulating bacteria have higher growth and survival than non-treated shrimp

On the contrary, survival of shrimp exposed to lethal dose of ammonia did not significantly differ between PHB-accumulating bacteria-fed shrimp and non-PHB treated shrimp. Current data clearly illustrate that indigenous bacilli capable of accumulating PHB can provide beneficial effects to *P. monodon* postlarvae during culture in terms of growth performance, survival and resistance against pathogenic infection.

Another indigenous probiont (*Bacillus subtilis* G100R11) possessing antimicrobial and quorum-sensing activity against *V. harveyi*, a known pathogen in mud crab hatcheries, was also



Penaeus monodon shrimp larvae

isolated from the rearing environment, body surface, and gastro-intestinal tract of mud crab. Simulated hatchery runs showed that oral administration of *B. subtilis* could confer protection in mud crab as evidenced by the successful production of crab instar with a survival rate of 1%, which is better than the commercial probiotic control with 0% survival. Confirmatory trials are ongoing.

As for the application of diagnostics to ensure biosecurity, two major oyster-producing areas located in (a) Cabugao Bay along the coastal barangay of Brgy. Basiao, municipality of Ivisan and (b) Agojo River, Brgy. Agojo, municipality of Panay, were respectively investigated for their sanitary quality. Water samples were collected from three sampling stations (Stn) in Brgy. Basiao and examined for fecal coliform count. Oysters were also collected and examined for *E. coli* count and presence of *V. cholerae*, *V. parahaemolyticus*, and *Salmonella* spp. On the contrary, only water samples for fecal coliform determination were collected from Agojo river; downstream (Stn 1), midstream (Stn 2), and upstream (Stn 3) over the past three months (June to August). The mean body weight of oysters collected from the 3 stations in Brgy. Basiao ranged from 39-48 g, 44-

49 g, and 52-59 g from June to August, respectively. Higher coliform counts were persistently noted for water samples collected from Stn 1 and 2 in Agojo River in June as evidenced by mean coliform counts of 240 MPN/100 ml and 295 MPN/100 ml.

On the contrary, lower coliform counts were obtained for Stn 3 as evidenced by mean coliform counts ranging from 30.5 MPN/100 ml (June) to 78.5 MPN/100 ml (August). Lower coliform counts (i.e. 5 to 33 MPN/100 ml) were noted in the rearing water collected from the three stations in Brgy. Basiao. The mean *E. coli* counts obtained for Stn 1 apparently increased from 2,100 MPN/100 g in June to 49,500 MPN/100g in August. These values are above the microbiological standard set by EU for "Class A" production area. Lower *V. parahaemolyticus* counts (<3.0 MPN/g) and absence of *V. cholerae* were noted in all oysters examined. While none of the samples examined were positive in June, oysters collected from Stn 1 and 2 were positive for *Salmonella* in August. No significant differences were noted in the water temperature (29-30°C), DO (4.39 to 5.67 mg/L), and pH (7.2 to 8.4) of all stations monitored. Due to heavy rains, water salinity in Stn 2 of Brgy. Agojo dropped by about

8 ppt in August. Similar trend was also noted for the sampling stations in Brgy. Basiao. Because oyster production areas located in Barangay Cabugao examined in 2014 were identified as “Class C” based on *EU Shellfish Harvesting Area Classification Criteria*, three sampling stations in the deeper portion of Cabugao Bay, approximately 1 to 1.5 km away from the aforementioned areas, were chosen as potential stations for relaying experiment. Oysters that will be used for the relaying and depuration experiments will be collected from the aforementioned oyster production areas.

The quantity and composition of *Aeromonas* spp. in the rearing water, sediment, gills and intestines of tilapia

Oreochromis niloticus collected every two weeks from Day 30 to Day 120 after stocking for grow-out culture in six earthen brackishwater ponds were also investigated. *Aeromonas* spp. are known opportunistic pathogens of tilapia. The presumptive *Aeromonas* counts in the water and sediment ranged from 10^1 – 10^3 c.f.u. ml⁻¹/c.f.u. g⁻¹ while in the gills and intestines of tilapia, counts ranged from 10^4 – 10^7 c.f.u. g⁻¹ and 10^2 – 10^5 c.f.u. g⁻¹, respectively. In terms of composition, a total of 3 species were identified with the dominance of *A. hydrophila* (n=323) followed by *A. sobria* (n=14) and *A. salmonicida* (n=6) in all samples examined. Moreover, since the use of commercial antibiotics has been a common practice in tilapia

hatchery and grow-out culture operations as prophylactic or therapeutic agent, the resistance of *Aeromonas* species isolated from the water, sediment, gills and intestines of tilapia to 10 antibiotics commonly used in tilapia culture was also investigated. More than 95% of *Aeromonas* species tested were resistant to amoxicillin followed by erythromycin (92%), neomycin (90%) and oxytetracycline (86%). Only 2% of the strains exhibited resistance to chloramphenicol and none to norfloxacin. The multiple antibiotic resistance (MAR) indexing of *A. hydrophila* strains tested generally showed that they originated from high-risk sources.

Promote wider use of conventional and new diagnostic methods for newly reported, emerging diseases

Diseases affecting farmed and wild mud crab including predisposing, risk and protective factors, and possible prevention and control measures for the diseases were studied. External examination of mud crab samples collected from the wild and grow-out ponds showed several abnormalities such as short abdominal flap; discoloration (blackish, rusty, reddish/pinkish) of the abdominal region; darker carapace, (necrotized) holes on carapace, claw and legs; presence of *lumut*/fouling organisms; and presence of barnacles *Balanus* sp. on the carapace. Internally, necrotic gills, black/brown gills, and discolored gonads (black, greenish) were observed. Stalked barnacles, *Octolasmis* spp. were observed in the gills. Among the known viral diseases, only white spot syndrome virus (WSSV) and infectious hypodermal and haematopoietic necrosis virus (IHHNV) were detected with WSSV solely implicated in mortality cases. Identified risk factors for WSSV include low temperature and presence of WSSV positive shrimp. A total of 1,450 bacterial isolates were also recovered from the hemolymph. Pathogenicity tests of 20 representative bacteria isolated in pure form suggested that these



PHOTO BY RH LEDESMA

Bacterial isolates biobanked at SEAFDEC/AQD

opportunistic bacteria could only induce mortality when mud crabs are stressed such as when they are newly molted.

Currently, there is lack of a comprehensive online information resource on shrimp pathogens with a centralized facility to

store and archive isolates collected from outbreaks all over the country. To fill this need, a database of aquatic pathogens occurring in the country was recently instituted to ensure sustainability of the Philippine aquaculture industry. Samples from shrimp farms in different regions in the country were collected. A total of 1,321 bacterial isolates were collected and biobanked. These samples came from 79 countrywide sites covering regions in Luzon, Visayas, and Mindanao. Twenty-seven of these sites have experienced diseases such as WSSV, luminous vibriosis, IHNV, MBV, and AHPND. To obtain meaningful information from the data generated, database software intended for web-based accessibility by users was developed using the free MySQL

1,321
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sites in Luzon, Visayas
and Mindanao and
biobanked

format and the USGS AquapathogenX template for information fields. The biological data are accompanied by epidemiological information collected on

site during sample collection. A Biobank Room dedicated for storing and archiving isolates that is compliant to at least level 2 biosafety and biosecurity standards has been recently established in AQD.

In conjunction with the ongoing study on the development of shrimp pathogen diagnostic tools using nested PCR and lateral flow strip biosensors (LFSB) coupled with a mobile app and cloud-based information management, preliminary data revealed that the detection limit of LFSB kit is at par with 1-step WSSV PCR method. Refinements are currently being undertaken to improve the detection limit of LFSB kit (i.e. to be at par with the nested-step of the optimized WSSV PCR method).

Find effective and alternative safe drugs and chemicals to manage diseases

Infectious diseases of bacterial etiology are some of the constraints limiting mud crab hatchery production. Lack of alternatives to antibiotics (in which use has been banned or discouraged due to food safety concerns) has hampered the production of adequate seeds to

spur production in grow-out facilities. Two plant extracts (*Terminalia catappa* local name: talisay and *Nephelium lappaceum* local name: rambutan) were tested to have antimicrobial activity *in vitro* (agar disc diffusion method) and *in vivo* (oral administration followed by

bacterial challenge). Simulated hatchery runs showed that oral administration of *T. catappa* successfully produced crab instar with a survival rate of 1.2% and 1.8% in trials 1 and 2 comparable to antibiotic control.

The **ABOT (Agree-Build-Operate-Transfer) AquaNegosyo** is one of SEAFDEC/AQD's programs to accelerate the promotion and adoption of sustainable tropical aquaculture technologies by the private sector.

This includes preparation of aquaculture business packages and provision of technical assistance to aquaculture farmers and investors in the Philippines and abroad.

Business Packages

Species	Hatchery & nursery	Grow-out
 Abalone	✓	✓
 Mud crab	✓	✓
 Grouper	✓	✓
 Milkfish	✓	✓
 Seabass	✓	✓
 Snapper	✓	✓
 Rabbitfish	✓	✓
 Pompano	✓	✓
 Catfish	✓	✓
 Tilapia	✓	✓
 Carp	✓	✓
 Giant freshwater prawn	✓	✓
 Tiger shrimp	✓	✓*
 Seaweeds		✓

*Greenwater culture of tiger shrimp, tilapia and milkfish

Maintaining Environmental Integrity Through Responsible Aquaculture (MEITRA)



PHOTO BY J ALTAMIRANO

A floating sea cucumber nursery module and monitoring station at Polopiña Island, Concepcion, Iloilo

RATIONALE

The MEITRA Program was developed to address issues on the negative impacts of aquaculture on the environment and how these impacts will be minimized. Its goal is to develop environment-based aquaculture technology by integrating environmental factors in SEAFDEC/AQD research activities and to maintain environmental integrity by promoting responsible aquaculture practices.

Develop environment-based aquaculture technology and promote responsible aquaculture practices

OBJECTIVES

1. Assess impacts of aquaculture on biodiversity, and water and sediment qualities in the culture areas and adjacent ecosystems both in marine and freshwater systems
2. Identify appropriate extractive species that may be used in *Integrated Multi-trophic Aquaculture* (IMTA)
3. Develop and promote efficient and suitable environment-friendly culture systems
4. Conduct biological and ecological studies on species with potential for resource enhancement

Assess impacts on biodiversity, water and sediment qualities in culture areas and adjacent ecosystems

The impact of the aquaculture activities in the different stations of SEAFDEC/AQD (IMS, TMS, and BFS) was assessed in terms of water and sediment quality, as well as diversity of aquatic organisms. Results have been

varied with IMS showing some benefit of aquaculture structures attracting organisms (mainly found attached to nets and other structures). Studies on DBS conducted in previous years also showed that DBS ponds and mangroves are still

biodiverse systems despite intended monoculture for many years. On the other hand, in BFS, significantly lower fish diversity was observed in the aquaculture site, compared with that of an adjacent, non-aquaculture site.

Identify appropriate extractive species for IMTA

The *Integrated Multi-trophic Aquaculture* using a combination of milkfish, sandfish and seaweeds is on-going with funds from JIRCAS. The study aims to quantify the extent of eutrophication caused by aquaculture. Milkfish, sandfish and seaweeds were stocked in pens at Brgy. Pandaraonan, Nueva Valencia, Guimaras; and is being monitored for environmental,

as well as, production parameters. Data from this experiment will be used to estimate nutrient flow within an IMTA system. In a separate milkfish mariculture site, monitoring of temperature, tidal current, *in situ* chlorophyll fluorescence, dissolved oxygen and other parameters are also on-going. The data obtained from these studies will be used to create a

numerical model of nutrient flow within a milkfish mariculture system. With the quantitative elucidation of the extent of eutrophication from aquaculture, appropriate management conditions for IMTA operation can be implemented.

Develop and promote efficient and suitable environment-friendly culture systems

A number of studies under this objective are underway for the following commodities: sandfish *Holothuria scabra*, abalone *Haliotis asinina*, slipper oyster *Crassostrea iredalei*, giant freshwater prawn *Macrobrachium rosenbergii*, and seaweed *Caulerpa lentillifera*.

For sandfish, two experimental nursery sites have been established in Brgy. Pandaraonan, near IMS and in an open bay in Polopiña Island, Concepcion, Iloilo. For the sea ranch sites, after extensive site evaluation, the best sites selected were in Sitio Looc, also in Polopiña Island and

in Brgy. Pandaraonan, Nueva Valencia, Guimaras. Formal agreements with the concerned local government units and concerned communities' People's Organizations have been finalized. Social resource mapping was also conducted as part of the process to engage local

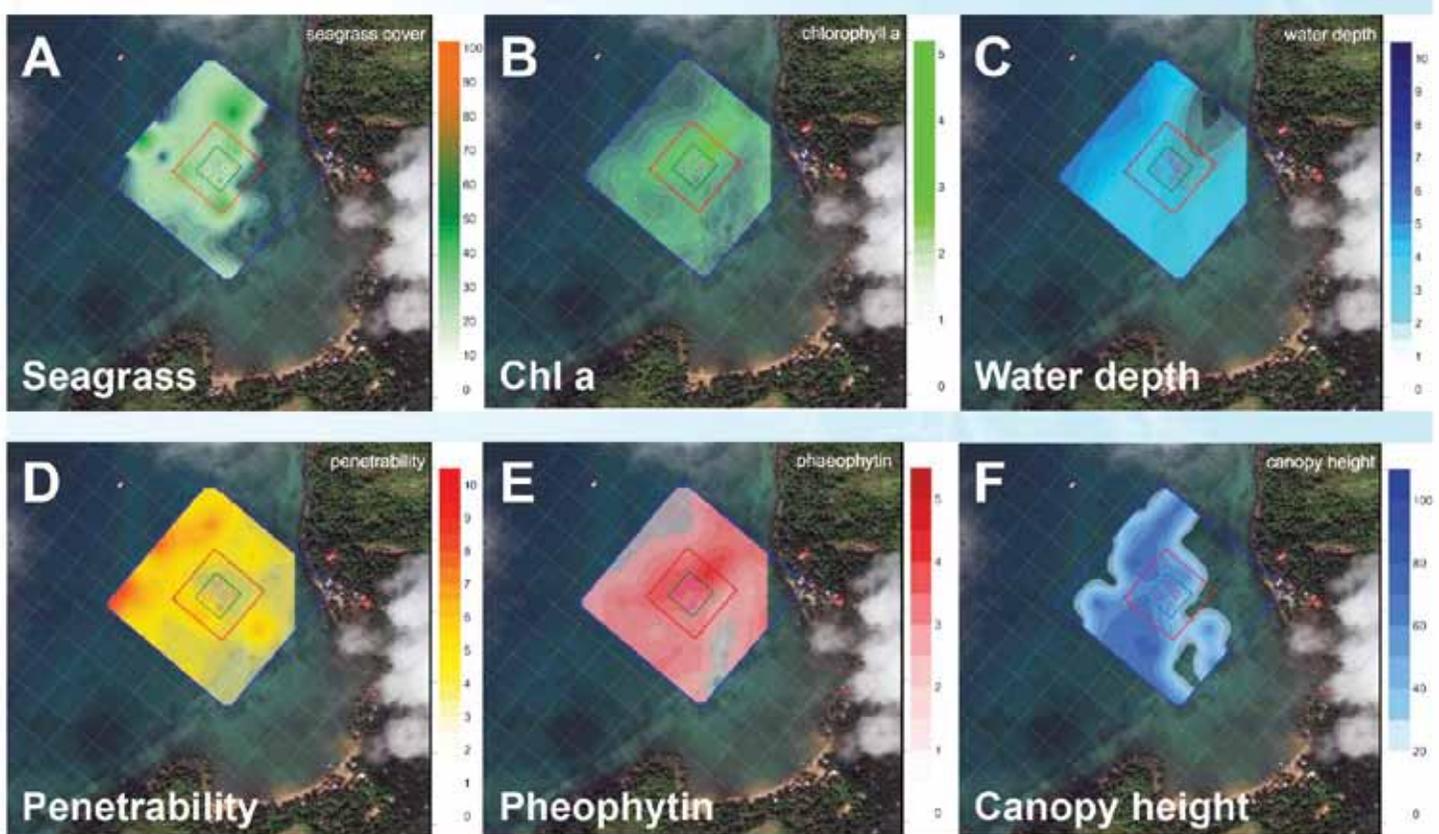


PHOTO BY JALTAMIRANO

Baseline environmental assessment for the Polopiña sea ranch site, (A) seagrass cover, (B) chlorophyll a, (C) water depth, (D) penetrability, (E) pheophytin, and (F) canopy height

communities into active participation in the project. Nursery of sandfish was also set-up at a local college, Northern Iloilo Polytechnic State College-Concepcion, for the production of sandfish juveniles.

Nursery trials for abalone have shown that mean shell length and body weight of juveniles reared in reef flats and in concrete tanks were inversely proportional to stocking density with the optimum stocking density of 400 ind/m² (other densities tested were 100, 200, 800 and 1000 ind/m²) in both rearing environments. Grow-out trials in a reef flat gave the highest shell length and best survival at a stocking density of 50 ind/m² (other densities tested were 100, 200, 400 and 500 ind/m²).

Refinement of grow-out techniques for the slipper oyster *Crassostrea iredalei* is also underway with the pouch method of grow-out giving the best result. Thirty 90 x 50 cm pouches with 25 compartments each, were hung on three 1.5 x 2 m rafts in two sites: Batan Bay in New Washington, Aklan and in Dumangas, Iloilo. Each site has 2,250 pieces of oysters. Spats used in both sites were harvested from New Washington, Aklan. Another site is in Ajuy, Iloilo where grow-out was incorporated as part of the IMTA project.

Based on the results of the IMTA experiment in pens in Ajuy, Iloilo, milkfish may be grown with other aquaculture organisms without affecting their growth and survival. Although no significant differences have been observed between treatments, milkfish had the highest survival when grown in combination with oysters, seaweeds and imbao. Mean body weight, though lowest in treatment 'All' upon harvest, showed no significant differences between treatments. Co-culture of organisms from different trophic levels in an integrated multitrophic aquaculture system is a better alternative compared with a monoculture system.

Biofloc system is currently being tested for the culture of the giant freshwater prawn using different sources of carbon (molasses, table sugar or potato starch). Juvenile prawns were stocked in indoor polyethylene tanks. Prawns were fed daily a 25% crude protein commercial feed and each tank was dosed daily with



PHOTOS BY JALTIMIRANO

Social resource mapping activity where the local community actively participates



Experimental hatchery facility at NIPSC-Concepcion used in sandfish spawning and rearing



PHOTO BY MUJL RAMOS

Oyster spats reared in pouches



Harvesting oyster pouches after 6 months of culture



PHOTOS BY MJHL RAMOS / IT TENDENCIA

appropriate volume of stock solutions of the different carbon sources to come up with an N to C ratio of at least 14. Each tank was provided with vigorous aeration to keep the biofloc suspended and artificial substrates made of rolled stiff netting material was provided in each tank. Unlike in the control tanks (no biofloc) where water was replaced weekly, there was no water replacement in the biofloc treatments, only minor addition of water to compensate for evaporative losses. Based on the 3-month results, no significant differences in growth and survival among all treatments and control were observed. Ammonia in the different treatment was not significantly different, even in the biofloc treatments indicating the biofloc was able to process ammonia from the system despite no water replacement.

The optimization of culture of the seaweed *Caulerpa lentillifera* in tanks and ponds is being investigated. Experiments on different levels of nitrogen, irradiance and salinity for *C. lentillifera* culture are on-going. In the nitrogen trials, results showed that gross photosynthesis (GP) was obtained in treatments without fertilizer and 0.6 ppm N at 210 $\mu\text{mol photons m}^{-1} \text{sec}^{-1}$. GP was highest at salinities of 25 and 30 ppt, at 110 $\mu\text{mol photons m}^{-1} \text{sec}^{-1}$. No significant differences in chlorophyll a and b were noted at treatments with no

fertilizer, with 1.2 and 1.8 mM NaNO_3 at all irradiance levels. Seaweeds cultured at 15 ppt died at week 2 while growth was not significantly different at 25, 30, and 34 ppt. Also, there was no significant difference in chlorophyll a and b content at 15, 25 and 30 ppt at four irradiance levels investigated.

The culture of shrimp in an aquasilviculture system has just started. A suitable experimental pond site, located in Nabitasan, Leganes, Iloilo has been selected. A Memorandum of Agreement between SEAFDEC and Leganes LGU

regarding the use of the ponds has been signed. The study will determine the following parameters: the time required for a mangrove habitat to remove nutrients (i.e. N, P) from shrimp farm effluents; appropriate pond to mangrove area ratio that will efficiently remove nutrients from shrimp pond effluent; factors affecting mangrove efficiency to remove nutrients (i.e. surface area mangrove species, bark, leaf litter, etc); and promote the aquasilviculture of shrimp as an ecosystem based management strategy for increased production in ASEAN member countries.



Oysters harvested from oyster pouches

Conduct biological and ecological studies on species with potentials for resource enhancement

The promotion of the resource enhancement of seahorse was initiated. Under this activity: (1) appropriate transport and acclimation strategies from the hatchery to the release site will be developed, (2) appropriate size and the time of day of release will be determined, (3) appropriate monitoring strategies of the released stocks will be developed, and (4) recovery, growth and survival of the released stocks will be assessed. The involvement of the local community in the management of the natural resources will also be promoted as part of the activities of the study. These studies are part of the GOJ-funded initiative under the *Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources* Program and are reported in the GOJ-TF section of this publication.



PHOTO FROM THE AGD ARCHIVE

Sampling of seahorse in Molocaboc Island, Sagay City, Negros Occidental



Newborn seahorse (8 mm) [top] and 4-month old juvenile seahorse (4 cm) [bottom]



PHOTOS BY SMB URSUA/IT TENDENCIARH LEDESMA

Seahorse species reared at SEAFDEC/AQD (L-R): *Hippocampus comes*, *H. barbouri* and *H. spinosissimus*

Adapting to climate change (CC)

RATIONALE

In recent years, several parts of the world have experienced abnormal weather patterns/disturbances like extended dry spells that lead to intense drought, frequent heavy rains resulting to severe flooding, more frequent and stronger typhoons and hurricanes, among others. The occurrence of these abnormalities was largely attributed to global climate change.

The changes in the climate are projected to impact broadly across ecosystems increasing pressures on livelihoods and food supply chains, including the fisheries and aquaculture sectors. The future food supply will be a central issue as food resources come under greater pressure. In particular, the sustainability of aquaculture will be further challenged since the effects of these climatic changes are largely unknown. Small-scale fish farmers in the region that produce the bulk of aquaculture production are largely vulnerable since they are dependent on aquaculture operations for food and income. Urgent adaptation measures are therefore required in response to the threats to food and livelihood provision that may arise due to the changing climatic conditions.

Identify changes in the environment that may affect aquaculture, prepare for possible effects, minimize and mitigate the impacts, and ensure continued aquaculture production under changing climatic conditions

OBJECTIVES

1. Gather scientific information on the susceptibilities of various economically important aquaculture species to the combined effects of high seawater temperature and acidity
2. Generate scientific data on the effects of abrupt changes in water temperature and salinity brought about by long dry spells followed by heavy rains in the outdoor production of natural live food organisms for hatcheries and for pond culture systems
3. Promote awareness among fish farmers and the general public on the possible effects of climate change to aquaculture operations
4. Assist government agencies in the country and in the region in gathering baseline information on aquaculture areas/sites that are most vulnerable to climate change effects/impacts
5. Collaborate with other institutions in the country and in the region in gathering baseline information on the effects of climate change to the mangrove ecosystem
6. Explore potential adaptive measures to mitigate the impact(s) of climate change to different aquatic farming systems
7. Collaborate with other institutions in the country and in the region in gathering scientific information that will serve as basis for the formulation/design of alternative aquaculture systems that are adaptive to climate change

It was demonstrated previously in rabbitfish *Siganus guttatus* that gonadal development and spawning success was still high even at elevated temperatures with a 31-33°C range. On the other hand, eggs of milkfish *Chanos chanos*, Asian sea bass *Lates calcarifer* and rabbitfish were aborted at 33°C while a lower hatching rate was observed at 31°C. Elevated temperatures were also shown to be detrimental to the larval survival of the three species with rabbitfish unable to survive at all at 33°C.

Generate scientific information on the effects of elevated water temperature on the reproductive performance of economically important marine aquaculture fishes

Considering the importance of milkfish to the aquaculture industry, it is necessary to

study the effects of changes in climate on its reproductive performance. Historical data (gathered over 10-15 years) on the reproductive performance of different spawning stocks of milkfish will be reviewed and correlated with data on relevant environmental parameters (e.g. temperature, rainfall and occurrences of weather disturbances) to see any trends. Although there are anecdotal reports of reduced incidence of spawning in other species during extended dry and hot spells (e.g. tilapia, shrimp, mud crab, abalone), this is not very clear among captive milkfish broodstock. Also necessary are innovations in aquaculture management and culture practices to mitigate the impacts of climate change. Additionally, identification of new or potential aquaculture species that are resilient to climate change should be considered.

Increase the awareness of the fish farmers and general public on the possible effects of climate change to aquaculture operations

With improved public awareness and understanding on the issue of climate change, the better prepared the public will be in facing the challenges posed. The AQD Library is continuously sending updates and new information about the effects of climate change to aquaculture to all the staff and other interested stakeholders. In addition, the training courses offered by AQD contain a lecture on this issue since 2013. Based on the feedback received from the trainees, the inclusion of this lecture topic in the training courses was very much appreciated since they are now aware of this very important issue that will likely affect their future aquaculture ventures.

Meeting Social and Economic Challenges in Aquaculture Program (MSECAP)



PHOTO BY RJ CASTEL

SEAFDEC/AQD technical staff supervise members of the Molocaboc Sea Rancher's Association doing the collection of sandfish broodstock

RATIONALE

MSECAP recognizes the need to secure food and income by developing and implementing social and economic strategies in aquaculture and resource management through collaboration with stakeholders. This program aims to respond to specific recommendations for meeting the social and economic challenges in aquaculture identified and adopted during the ASEAN-SEAFDEC Fish for the People Conference in 2011.

Develop and implement social & economic strategies in aquaculture and resource management

OBJECTIVES

1. Prioritize collaborative R&D in aquaculture in the region to understand the role of aquaculture in poverty alleviation and provide basis for policy formulation
2. Allocate R&D resources to address emerging issues with emphasis on small-holder fish farmers
3. Enhance multi-agency collaboration, sharing of information and resources between and among SEAFDEC and its Member Countries and other organizations

Prioritize collaborative R&D in aquaculture in the region

Research studies in MSECAP promote the dissemination and adoption of sustainable aquaculture technologies for fisherfolk. Ten fisherfolk in Brgy. Pipindan in Laguna Lake were trained on hatchery and nursery rearing of giant freshwater prawn, *Macrobrachium rosenbergii*. Prawn post-larvae (PL) harvests of trainees were either sold to other fish farmers or reared by the trainees with tilapia at 750 pieces of each species

in 5 x 10 m hapa net cage to improve income from monoculture operations.

In coastal areas, the integrated multi-trophic aquaculture (IMTA) of milkfish, *Chanos chanos*, with sandfish, *Holothuria scabra*, and seaweeds, *Kappaphycus* sp., were introduced to fishing families in Nueva Valencia, Guimaras to demonstrate the potential of IMTA in mitigating the impacts of excess

nutrients from uneaten milkfish feeds and feces while obtaining additional income from other non-fed species. For the first crop, three fishing family cooperators managed a 5 x 5 m pen each stocked with 500 pieces milkfish fingerlings, 66 sandfish individuals and 10 kg seaweeds. Milkfish harvest, 3 pieces/kg-size, were sold by fisherfolks while seaweed and sandfish harvest would be re-stocked for the next crop.



PHOTOS BY ND SALAYO

Seminar on family-based IMTA of milkfish, sandfish and seaweeds in Guimaras (left photo), monthly sampling of IMTA set-up conducted with fisherfolk cooperators (middle photo), and sorting of milkfish harvest by AQD researchers and fisherfolks while a fish trader buys fish for retail sale in local market (right photo)

Allocate R&D resources to address emerging issues

MSECAP embraced the emerging role of aquaculture in providing seeds for resource enhancement. Seed production is necessary to sustain the benefits from stocking of threatened species such as abalone, *Haliotis asinina*, accomplished in prior years in collaboration with stakeholder in Brgy Molocaboc in Sagay Marine Reserve. The Sagay City government committed to build a solar-powered hatchery after witnessing the successful enhancement of >2.5 cm abalone seeds, now harvested at 145 g each on average, in the demo-site in Molocaboc.

Sandfish seed production started with collection of broodstocks from Sagay and bred in AQD hatchery. Early juveniles were transported to Sagay. Fisherfolks participated in the nursery rearing of 20,850 early juveniles (~5 mm length) stocked in August and October batches in 2 x 1 x 1 m hapa cages at 1,000 pieces/cage. Survival rates varied from 70% (1.36 g average weight) on the first monitoring month to 4.3% (2.54 g weight) on the second month due to crab predators. A total of 3,200 juveniles (>2 g weight) have already been released in pens in December 2015; and subsequently in sea ranch site. Monitoring was conducted with fisherfolk and local students who glean sandfish for cash income.



PHOTOS BY RJ CASTEL / JP ALTAMIRANO / ND SALAYO



(Clockwise from top left) Deployment of hapa net cages for nursery rearing of hatchery-bred sandfish juveniles for sea ranching; local students participate in monitoring weight and survival of sandfish; and newly elected officers of the Molocaboc Sea Ranchers Association (MOSRA) with BFARMC Officers and members, Sagay Marine Reserve staff and AQD researchers

Enhance multi-agency collaboration at the local and international levels

The program continues to promote aquaculture technology in the intermediate culture of tiger shrimp, *Penaeus monodon*, for release through a community-based stock enhancement project in New Washington tributaries in Aklan, Philippines. Local fisherfolk participated in the intermediate culture of postlarvae sourced from private hatcheries near the release site. Although some fishers now catch mature shrimps, there are still economic losses since

under-sized fishes are caught by using illegal fine meshed net gears.

Market and consumption studies were also conducted to evaluate investment opportunities in the culture of rare high-value indigenous fish species. These indigenous fish species include silver therapon or ayungin, *Leiopotherapon plumbeus*, in Laguna Lake; giant trevally or maliputo, *Caranx ignobilis*, in Taal Lake; lobed river mullet or ludong,

Cestraeus sp., in Cagayan River; and tapiroid grunter or bulidao, *Mesopristes* sp., in Abra River. Results indicate that the private sector may invest in the grow-out and breeding of giant trevally and silver therapon as high market demand and prices for these species can overcome cost of culture. Meanwhile, public investments on further studies on the biology of rare lobed river mullet and tapiroid grunter is recommended.



Tagged *P. monodon* (1g) before release (inset) and mature size (100g) caught by a fisherman four months after release (left photo) and students of Aklan State University participate in monthly monitoring of fish catch and water quality in the New Washington tributaries together with AQD and RIHN researchers (above photo)



(Clockwise from top left) Under-sized ayungin commonly caught and sold in markets around Laguna Lake; maliputo cage culture in Taal Lake; and maliputo fingerlings being sold in Lemery, Batangas for stocking in cages in Taal Lake

PHOTOS BY C RECENTE / ND SALAYO

PHOTOS BY CF AYA / FAAYA / ND SALAYO

Promotion of Sustainable Aquaculture and Resource Enhancement in Southeast Asia

SEAFDEC/AQD, through the Government of Japan Trust Fund (JTF6), has continued implementing the regional program *Promotion of sustainable aquaculture and resource enhancement in Southeast Asia* under the ASEAN-

SEAFDEC Fisheries Consultative Group Program. The following are the projects under this program which are being implemented in collaboration with several research partners in the ASEAN region: (a) reinforcement and optimization

of fish health management and effective dissemination in the Southeast Asian Region, and (b) environment-friendly, sustainable utilization and management of fisheries and aquaculture resources.

Reinforcement and optimization of fish health management and effective dissemination in the Southeast Asian Region

The objectives of this project are to: (1) develop and accelerate rapid and effective fish and shrimp health management, (2) enhance efficacy of vaccine treatment in tropical cultured species, (3) establish protective measures against persistent and emerging parasitic diseases of tropical fish, (4) identify risk factors and develop protective measures against Early Mortality Syndrome (EMS)/ acute hepatopancreatic necrosis disease (AHPND) in *Penaeus monodon*, and (5) extend and demonstrate technology to practitioners, officers, and other stakeholders of member countries.

Development and acceleration of rapid and effective fish and shrimp health management

Early detection of devastating pathogens is the most efficient response to be able to implement immediate and appropriate interventions to control the spread of infection. One of the main objectives of this study is to determine the threshold levels of infection of various pathogens that will enable the farmer to strictly monitor the health status so that early and effective intervention strategies can be implemented.

Enhancement of vaccine efficacy for the prevention of viral nervous necrosis in high value marine fish

The field efficacy of the inactivated VNN vaccine in pompano reared in floating net cages in Igang Marine Station, Guimaras is currently being investigated. Pompano juveniles (n=1,600) with mean body weight of 5.7 ± 0.4 g were intraperitoneally vaccinated with the inactivated VNN vaccine (pre-inactivation titer: $10^{9.2}$ TCID₅₀/ml) and randomly divided into 2 groups, i.e. 800 individuals per $2 \text{ m} \times 2 \text{ m} \times 1.5 \text{ m}$ net cage. The same number of fish was injected with L-15 to serve as control. Determination of VNN-neutralizing antibody titer in the sera and concomitant protection against VNN will be done at Days 30, 60, 90, 120 and 150 post-vaccination.

Application of adjuvants, carriers and RNAi technology to enhance the antiviral immune response of shrimp to WSSV

The efficacy of a microparticle-delivered recombinant WSSV VP28 sub-unit vaccine for shrimp has been previously determined. The goal of the present

project is to determine the efficacy of a combined recombinant protein and dsRNA as antiviral treatment against WSSV. Preliminary experiments are in the pipeline to optimize conditions for the production of dsRNA and efficacy trials. These include LD₅₀ test, production of dsRNA from bacteria, and isolation of primary cells from shrimp lymphoid organs. The antiviral efficacy of the treatments will then be decided by *in vivo* challenge. LO primary cells have been successfully isolated but growth in L15 medium with supplements was not satisfactory and suggests further improvements in the medium are needed. WSSV infection was carried out and cells showed CPE at 10^{-5} dilution of the WSSV tissue filtrate.

Establishment of protective measures against persistent and emerging parasitic diseases of tropical fish

The aim of this study is to conduct pathogenicity, disease transmission and spatial distribution of monogenean, *Pseudorhabdosynochus lantauensis* in grouper. Experimental transmission showed 100, 80 and 53.33% mortality in fish stocked at 10 pcs/aquarium

(20 L) with infection levels of 800, 400 and 200 oncomiracidia per aquarium, respectively, by day 4 post-challenge. No mortality was observed among fish infected with 100 oncomiracidia and the control group. Histological analysis of gills showed hyperplasia and hypertrophy in fish infected with the highest concentration of the parasite (800 oncomiracidia). Mean number of parasites in gills were 61.50, 61.03, 64.4, 41.5 and 0 in fish challenged with 800, 400, 200, 100 and 0 oncomiracidia, respectively.

Epidemiology of the Early Mortality Syndrome (EMS)/acute hepatopancreatic necrosis disease (AHPND) in *Penaeus monodon*

The acute hepatopancreatic necrosis disease (AHPND) is one of the recent diseases that devastated the shrimp industry. Preliminary results of the study showed that 10^7 cfu/ml *Vibrio parahaemolyticus* in the rearing water can cause significant mortality in *P. monodon* PL (ABW > 0.38 g). The threshold level of AHPND bacteria in the environment, in the absence of stressor, which shrimp can eliminate from its body is 10^5 cfu/ml.



PHOTO BY CV GENZOLA

A demonstration on how to conduct fish necropsy

Pathogenic AHPND bacteria may lose its virulence/toxic genes; however, this needs further investigation.

Technology extension and demonstration

Activities delving on the status and needs of the primary aquatic animal health care in small-scale aquaculture in developing countries in Southeast Asia including Myanmar, Cambodia, Lao PDR, and the Philippines were undertaken under GOJ-TF5 Program. Substantial improvements

were noted on fish health (FH) worker's capacity to implement basic fish health (level 1) activities. However, further upgrading of FH worker's capacity to conduct levels 2 and 3 laboratory diagnostics requires immediate attention in order for these countries to be compliant with ASEAN Standards. To achieve this goal, follow up on-site training course and guided research designed for fish health personnel to keep abreast with diseases, especially those notifiable to the OIE, will be conducted in January 2016 in Myanmar.

Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources

The objectives of this project are to: (1) establish environment-friendly and responsible aquaculture technology, (2) promote community-based production and resource enhancement of high-value aquatic resources, and (3) disseminate and demonstrate resource enhancement practices.

Use of plant-based protein sources in tilapia feeds for improved production traits

A survey of major crop industries revealed high amount of wastes were generated after processing, and alternatives to its efficient utilization are necessary. Samples of agricultural residues and by-products (e.g. sugarcane bagasse, okara meal, pineapple peels, mango peels and kernels, banana peels, and



PHOTO BY IT TENDENCIA

Nile tilapia *Oreochromis niloticus*

citrus pulp) were collected to evaluate their potential as feed ingredients in tilapia diets. Nutrient composition of some agricultural residues had shown

their potential as either protein or energy sources in tilapia diets. Sugarcane bagasse was characterized by high fiber and carbohydrate, and low ash and fat

contents. Okara contained high protein, fat and carbohydrate levels. Pineapple peel has high carbohydrate and low fat and ash levels similar to sugarcane bagasse. Appropriate processing treatments to successfully convert these materials into valuable protein sources are currently being tested.

Responsible aquaculture through aquasilviculture

Diseases continue to devastate the shrimp industry. Aquasilviculture has the potential to mitigate disease occurrence and improve shrimp survival via an improved water quality. The capability of mangroves to improve water quality or remove nutrients from pond effluents depends on the ratio of mangrove forest to shrimp pond area (MPR). Reported MPR's varied and have a wide range. This study aims to determine the time required for a mangrove habitat to remove nutrients from shrimp farm effluents putting into consideration the MPR.

Community-based integrated production of abalone *Haliotis asinina* and sea cucumber *Holothuria scabra* through culture, sea ranching and stock enhancement

Local supply of hatchery-bred abalone and sandfish seeds are needed to sustain community-based stock enhancement initiatives in Molocaboc in Sagay Marine Reserve under JTF5. Thus, integrated

Training fellowships under GOJ-TF

The GOJ-TF granted seven fellowships to government extension workers from SEAFDEC member countries in two of the 24 training courses organized by SEAFDEC/AQD in 2015.

Course title	Fellowship granted (number of trainees)
Marine fish hatchery	Philippines (1), Indonesia (1), Malaysia (1), Viet Nam (1)
Community-based freshwater aquaculture for remote rural areas of Southeast Asia	Philippines (1), Thailand (1), Viet Nam (1)

production of these threatened species was included in SEAFDEC/AQD-JTF6 (2015-19). In 2015, fisherfolk participated in sandfish nursery rearing in cages and pens, construction of abalone demo-hatchery, and monitoring of stocks. Other activities aim to improve awareness and governance of released stocks.

Promotion of resource enhancement of seahorses

Wild seahorses (8-27 individuals) were monitored every month in Molocaboc Island in Sagay City. Sampling time coincided with the onset of high tide when natural food (mysids, etc.) comes

with the tide. Trials were conducted on transport and acclimation strategies on three size classes of juvenile seahorses: A=4.8±0.03 cm stretched height (SH), B=5.8±0.03 cm SH and C=7.1±0.02 cm SH at loading densities of 1 and 2 ind/L and transport durations of 10 and 12 h. Seahorses were acclimatized using intermediate enclosures hanged on a 5 x 5 m² floating bamboo raft. Results showed 100% survival after seven days post-transport. Participatory involvement of the community in management of the natural resources was on the hands-on training during monitoring and acclimation of seahorses.

Regular and Specialized Training



PHOTO BY R. PAGADOR

A practical activity on sea ranching site assessment during the training on “Sandfish (*Holothuria scabra*) Seed Production, Nursery and Management”

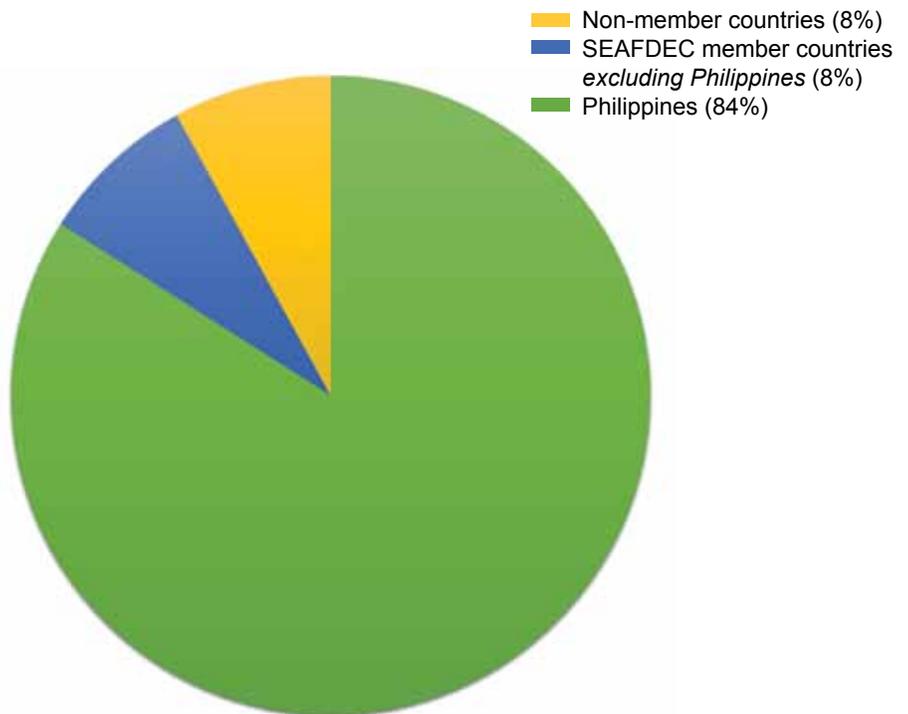
SEAFDEC/AQD’s Training and Information Division (TID) continued to build the capability of fishfarmers, the academe, and other stakeholders in the industry on sustainable aquaculture technologies through training, internship and research mentorship.

This year, TID conducted 30 sessions of 24 training courses that were attended by 299 trainees from 16 countries. A total of 275 training participants came from SEAFDEC member countries such as Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam. In addition, about 55% of the training participants were privately funded. TID also continued with its internship program that was availed by 30 interns, while student on-the-job training was availed by 254 students from 31 schools from all over the Philippines.

Soft-shell Crab Farming (Tigbauan Main Station [TMS], Tigbauan, Iloilo; 9-24 January and 16-21 March 2015). A specialized training course with lectures and practical sessions on biology of mud crab species; nursery management; grow-out culture in ponds, pens, and cages; and soft-shell production.

Milkfish Farm Management and Operations (TMS; 28 January-11 February 2015). A specialized training course with lectures on broodstock management and spawning techniques,

production of natural food organisms for fish larvae, and larval and nursery rearing techniques as well as practical sessions on fry collection, stock sampling, monitoring and harvest.



Participants of SEAFDEC/AQD’s training courses

Nursery and Grow-out Culture of Mud crab (Buenavista, Agusan Del Norte; 25-27 February 2015). An onsite training course with 60 participants from Zamboanga State College of Marine Sciences & Technology, the private sector and the local government unit of Zamboanga City. This course had lectures and practical sessions on mud crab biology, broodstock management & larval rearing, nursery rearing and natural food production.

Bighead Carp Hatchery and Grow-out Operations (Binangonan Freshwater Station [BFS], Tapao Point, Binangonan, Rizal; 20-24 April 2015). A specialized training course that covered topics on broodstock management, induced breeding and seed production, and nursery and grow-out operations. Hands-on practicals provided were broodstock selection; induced spawning; hormone preparation; egg stripping, fertilization and incubation; monitoring of embryonic development; hatching of *Artemia* cysts, harvesting of *Artemia*; determination of hatching rate; larval rearing; and fry harvesting, packing and transport.

Sandfish (*Holothuria scabra*) Seed Production, Nursery and Management (TMS; 21 April-5 May and 3-17 November 2015). A regular training course with lectures and practical sessions on topics such as broodstock management and spawning techniques, production of natural food organisms for sandfish larvae, larval and nursery rearing techniques, and grow-out management and processing of sandfish.

Abalone and *Kappaphycus* Culture (Estancia, Iloilo; 21-23 April 2015). A specialized training course funded by Ayala Corporation. This training course aimed to provide alternative livelihood to the displaced residents of Sicogon Island, Carles and the victims of typhoon Yolanda in Estancia, Iloilo relocated in Brgy. Jolog, Estancia, Iloilo. Lectures for the abalone training course include topics on biology & ecology and grow-out culture. There were also hands-on activities such as fabrication of culture containers, transport of abalone, and acclimatization & stocking. For the *Kappaphycus* culture course on the other hand, biology & ecology of seaweeds and grow-out culture of seaweed



A practical session on stocking of crablets during the mud crab training course in Agusan Del Norte

PHOTO BY CV GENZOLA



A practical session on abalone anatomy/ digestive physiology

PHOTO BY EV ANTOLINO

Kappaphycus were discussed. Hands-on activities include cutting of *Kappaphycus* branches and tying to polyethylene ropes, preparation of sinkers and buoys for the culture lines, and post-harvest processing of seaweeds.

Abalone Hatchery and Grow-out (TMS; 6-26 May 2015). A regular training course with lectures and practical sessions on biology, hatchery and seed production, grow-out culture, feeds and feeding, and culture of diatoms. Principles of sustainable aquaculture were also discussed.

Freshwater Prawn Hatchery and Grow-out Operations (BFS; 11-15 May 2015 and 14-18 September 2015). A specialized training course with lectures on biology and reproduction; broodstock, hatchery and nursery operations; grow-out culture in cages and ponds; and rice-prawn farming. Practical sessions include broodstock selection; fry harvesting, packing and transport; larval rearing; hatching and harvesting of *Artemia*; monitoring of larval stages; larval health management; water quality management; and postlarvae harvesting, packing and transport.

Viral Disease Detection in Crustaceans (TMS; 11-19 May 2015). A specialized training course with lectures on disease development in aquaculture, shrimp viral disease pathology and diagnosis, use of PCR and other molecular techniques in viral disease diagnosis, surveillance of shrimp viral pathogens, immune system of shrimp, bacterial diseases of shrimp with emphasis on EMS, and histological slide preparation and histopathology. Practical activities for this course were fry quality monitoring and enumeration, MBV detection in shrimp and by wet mount method, bacterial enumeration in water and in shrimp, and histological slide preparation.

Feed Formulation (TMS; 19-22 May 2015). A specialized training course sponsored by DOST-PCAARRD. Participants were researchers from Philippine state colleges and universities who are working on aquaculture and/or fisheries related research projects. Among the topics discussed were: *Industry Strategic Plan* for selected aquatic resources, role of fish nutrition and health management in sustainable aquaculture, feed formulation and evaluation for a feeding trial, major diseases of aquaculture species, prevention & control of diseases, and nutritional pathology. There were also practical sessions on feed preparation; feeding management in tanks, floating net cages, and brackishwater ponds; and disease diagnosis.

Training of trainers on ASEAN Shrimp Good Aquaculture Practices for BIMP-EAGA (TMS; 24 May-6 June 2015). A BFAR-funded training course that focused on four modules namely (1) food safety and quality, (2) animal health welfare, (3) environmental integrity, and (4) socioeconomic aspects. It covered lectures on the concept of sustainable aquaculture; management of shrimp broodstock; hatchery & grow-out; site selection; feeds & feeding; physical, biological, & chemical hazards; microbial contamination & sanitation; and responsible use of chemicals, antibacterial agents & the withdrawal period of these chemicals.



PHOTO BY CV GENZOLA

Participants of the training course *Training of trainers on ASEAN Shrimp Good Aquaculture Practices for BIMP-EAGA* interview the owner of a shrimp hatchery in Makato, Aklan



PHOTO BY R PAGADOR

Sampling of grouper broodstock at the hatchery

Mud crab Hatchery, Nursery and Grow-out Operations (TMS; 26 May-17 June 2015). A 23-day regular training course with lectures on concepts and principles of sustainable aquaculture, overview of the mud crab industry, biology of mud crab *Scylla* spp., culture of natural food organisms, broodstock management & larval rearing, grow-out culture in ponds & pens, fattening, and soft-shell crab

farming. There were also topics on feed formulation and preparation, economic evaluation of hatchery & nursery, mangrove management, food safety in aquaculture products, impacts of climate change, and diseases. Practical activities on the other hand include: natural food culture, anatomy & physiology, larval rearing, ablation and tagging, embryonic development & identification of larval

stages; nursery culture, pond preparation, feed preparation, pond management, and disease diagnostics among others.

Marine Fish Hatchery (TMS; 17 June-24 July 2015). A 37-day regular training course with topics on concepts and principles of sustainable aquaculture; biology of marine fishes such as milkfish (*Chanos chanos*), sea bass (*Lates calcarifer*), groupers (*Epinephelus coioides*, *E. fuscoguttatus*), mangrove red snapper (*Lutjanus argentimaculatus*), rabbitfish (*Siganus guttatus*) and pompano (*Trachinotus blochii*); broodstock management and spawning; hatchery design and construction; nutrient requirements of tropical marine fishes; feed formulation and preparation; diseases of tropical marine fishes; culture of live food organisms; biology and intensive rotifer production; and *Artemia* disinfection, hatching and enrichment. Practical activities include identification of marine fishes; collection of milkfish eggs; induced spawning and larval rearing of different marine fishes; culture of natural food; rotifer production; *Artemia* disinfection, hatching, and enrichment; feed preparation of nursery and grow-out feeds; and observation of fish cage culture.

Aquafeed Formulation (TMS; 17 June-1 July 2015). A specialized training course with lectures and practical activities on essential nutrients, nutrient requirement, feed formulation, feeding habits & behavior, and feed preparation & storage among others.

Catfish Hatchery and Grow-out (TMS; 17-21 August 2015). A specialized training course with lectures on biology and reproduction; broodstock selection and management; pond design; hatchery and nursery operations; and grow-out culture in tanks, cages and ponds. Practical activities include sex identification, broodstock selection and stocking (in tanks and cages); fabrication of fish farm implements, artificial incubators and net cages; induced spawning; determination of fertilization rate and monitoring of embryonic development; determination of hatching rate and stocking of larvae; larval rearing; and fry harvesting, packing and transport.



A trainee prepares fish and crustacean feed



Milkfish Cage Culture Operations and Management trainees learn to fabricate a cage framework

Tilapia Hatchery and Grow-out Operations (BFS; 24-28 August 2015 and 10-12 November 2015). A specialized training course that includes topics on biology and reproduction; genetics and sustainable management of farmed tilapias; broodstock selection and management; hatchery and nursery operations; and grow-out operations in tanks, cages and ponds. Practical activities cover sex identification; broodstock selection and stocking (in tanks and cages); methods for inducing sex reversal; and artificial egg incubation/fry sorting, harvesting, packing and transport.

Milkfish Culture (TMS; 10-12 September and 8-10 October 2015). A specialized training course specifically designed for Pilmico (a feed company) staff. This course had lectures and practical activities on milkfish culture from hatchery operations, broodstock management, grow-out culture in ponds and cages, fish nutrition and economics of culture.

Mud crab Hatchery and Nursery Operations (TMS; 21 September-12 October 2015). A 22-day specialized training course with lectures and practical sessions on the biology of mud crab *Scylla* spp., culture of natural food organisms, broodstock management &

larval rearing and diseases. Topics on principles of sustainable aquaculture, overview of the mud crab industry, feed formulation and preparation, food safety, and impacts of climate change were also discussed.

Mud crab Nursery and Grow-out Operations (TMS; 19-28 October 2015). A specialized training course with lectures and hands-on activities on biology of mud crab *Scylla* spp., broodstock management & larval rearing, grow-out culture in ponds & pens, feed formulation & preparation, and diseases. Other topics discussed were the principles of sustainable aquaculture, overview of mud crab industry, fattening, soft-shell crab farming, marketing, mangrove management, food safety, and impacts of climate change.

Milkfish Cage Culture Operations and Management (TMS; 20-29 October 2015). A specialized training course funded by FAO with lectures and practical activities on milkfish cage culture, feeds and feeding management.

Abalone Culture (TMS; 4-15 November 2015). A specialized training course for the technical staff of Western Philippines University. The course had lectures on the principles of abalone seed production, hatchery projections, and feeds and feeding. There were also hands-on activities such as feeding, selection/monitoring of breeders for spawning, culture of natural food, preparation of settlement plates, egg collection, stocking of breeders in spawning tanks, and cage fabrication.

Rabbitfish Broodstock Management and Larval Rearing (TMS; 16-20 November 2015). A specialized training course with lectures and practical activities on broodstock management, larval rearing, nutrition and feeding management.

Rabbitfish Culture (TMS; 16-30 November 2015). A specialized training course for the technical staff of Western Philippines University. This course had a lecture on broodstock management, induced spawning, and larval rearing;



A hands-on activity on selection of abalone breeders for spawning

PHOTO BY EVANTOLINO



Participants of the training course *Community-based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia* interact with members of the community to come up with a seasonal calendar of activities

PHOTO BY MH STINSON

and practical sessions on natural food culture, larval rearing, and counting of larvae among others.

Community-based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia (BFS; 24 November-3 December 2015). A regular training course with funding support from the Government of Japan-Trust Fund. This ten-day training course consisted primarily of lectures and practical activities on freshwater aquaculture technologies such as broodstock

development, seed production, as well as nursery and grow-out phase of tilapia, freshwater prawn, bighead carp and native catfish. Other topics discussed were genetics and sustainable management of farmed tilapias, diseases of freshwater fishes and food safety, business planning and management, and nutrition and feeding.

Information Dissemination



PHOTO BY GK FAIGANI

A stakeholder receives complimentary copies of newly released SEAFDEC/AQD publications during SEAFDEC/AQD's 42nd anniversary book launching activity

Science Papers

In 2015, SEAFDEC/AQD published a total of 40 scientific papers in ISI-CC & non-ISI-CC journals and conference proceedings. These papers are the outcome of the research work conducted at SEAFDEC/AQD or in collaboration with other institutions. These in turn, lays the foundation of science-based aquaculture technologies developed by the Department. The 2015 published papers are as follows:

Altamirano J, Kurokura H, Salayo N, Baticados D, Suyo JG, Ishikawa S. 2015. Community-based shrimp stock enhancement for coastal socio-ecological restoration in the Philippines. In: Romana-Eguia MRR, Parado-Esteva FD, Salayo ND, Lebata-Ramos MJH (eds). Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia: Challenges in Responsible Production of Aquatic Species. Proceedings of the International Workshop on Resource

Enhancement and Sustainable Aquaculture Practices in Southeast Asia 2014 (RESA); 5-7 March 2014; Iloilo City, Philippines. Iloilo, Philippines: SEAFDEC Aquaculture Department; pp. 159-167.

Apines-Amar MJS, Amar EC. 2015. Use of immunostimulants in shrimp culture: An update. In: Caipang CMA, Bacano-Maningas MBI, Fagutao FF (eds). Biotechnological Advances in Shrimp Health Management in the Philippines. Kerala, India: Research Signpost; pp 45-71.

Arnaiz MT. 2015. Chapter 3: Ethoxyquin. In: Coloso RM, Catacutan MR, Arnaiz MT. Important Findings and Recommendations on Chemical Use in Aquaculture in Southeast Asia. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department; pp. 16-17.

Arnaiz MT, Catacutan MR, Coloso RM. 2015. Chapter 2: Withdrawal periods of antibiotics, oxytetracycline and oxolinic acid, in fish species cultured in tropics. In: Coloso RM, Catacutan MR, Arnaiz MT. Important Findings and Recommendations on Chemical Use in Aquaculture in Southeast Asia. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department; pp. 11-15.

Aya FA, Nillasca VSN, Garcia LMB, Takagi Y. 2015. Embryonic and larval development of hatchery-reared silver therapon *Leiopotherapon plumbeus*(Perciformes: Terapontidae). Ichthyological Research 63:121-131.

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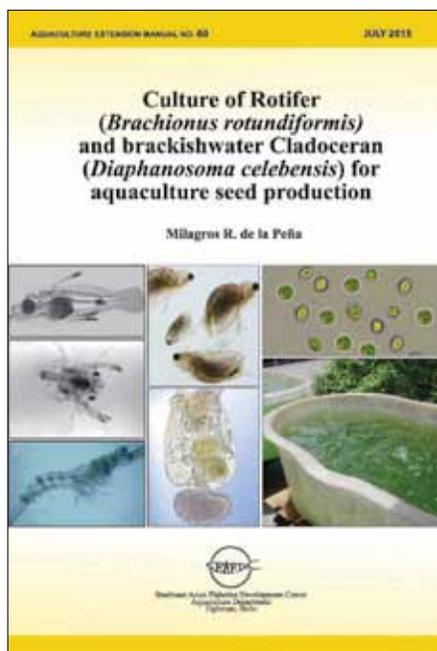
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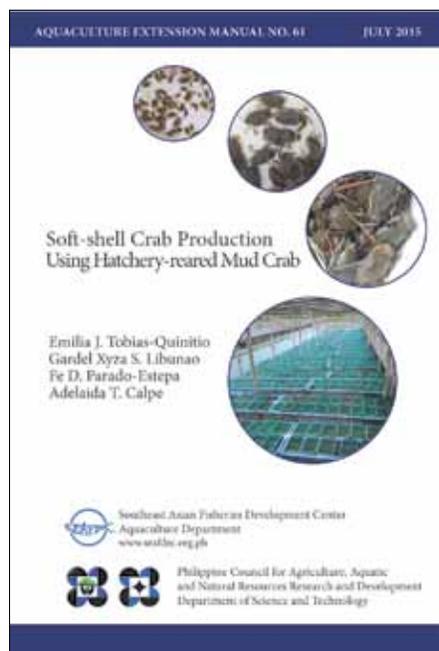
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Extension Manuals, Monographs and Conference Proceedings

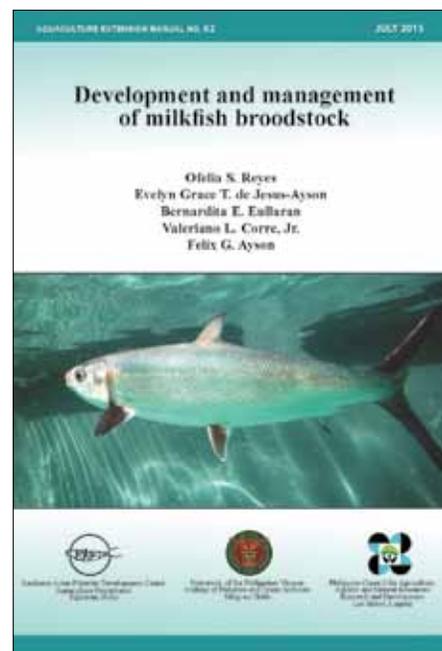
This 2015, SEAFDEC/AQD was able to produce three aquaculture extension manuals, two monographs, and two conference proceedings.



AEM 60 Culture of Rotifer (*Brachionus rotundiformis*) and Brackishwater Cladoceran (*Diaphanosoma celebensis*) for Aquaculture Seed Production by Milagros de la Peña. A 32-page manual with topics on the biology and cultivation techniques of zooplankton.



AEM 61 Soft-shell Crab Production using Hatchery-reared Mud crab by Emilia Tobias-Quinitio, Gardel Xyza Libunao, Fe D. Parado-Esteba, Adelaida Calpe. A 25-page manual describing the set-up and procedure in producing soft-shell crabs and its economic viability.



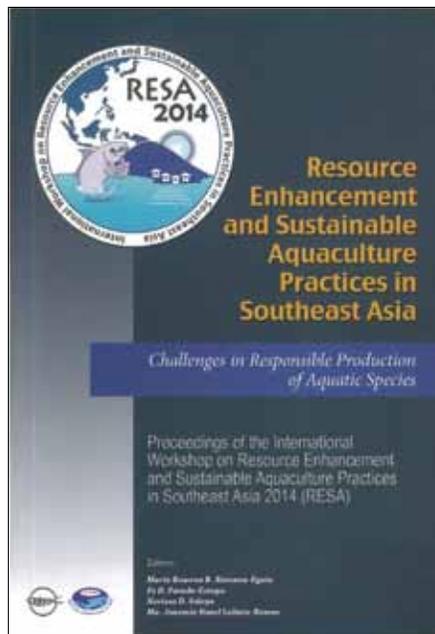
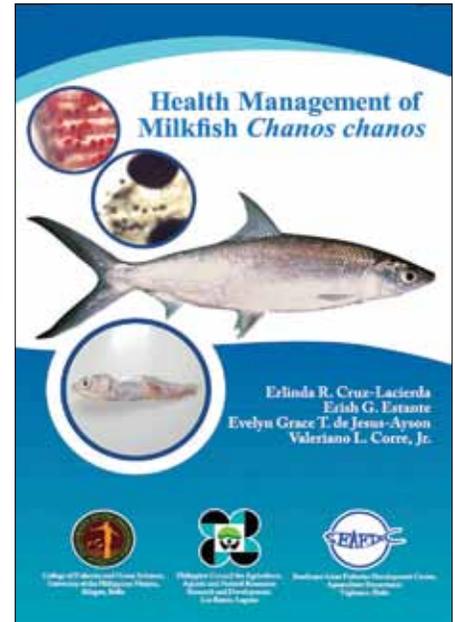
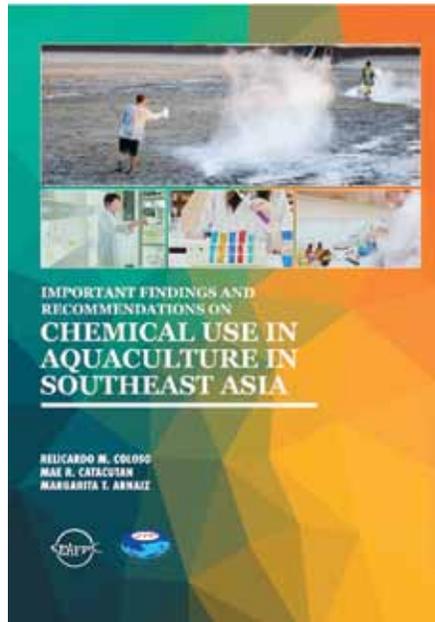
AEM 62 Development and Management of Milkfish Broodstock by Ofelia Reyes, Evelyn Grace de Jesus-Ayson, Bernardita Eullaran, Valeriano Corre Jr, Felix Ayson. A 33-page manual detailing the methods/procedures in managing milkfish broodstock.

Important Findings and Recommendations on Chemical Use in Aquaculture in Southeast Asia by Relicardo Coloso, Mae Catacutan, Margarita Arnaiz (eds). A 58-page monograph that contains important findings and recommendations on the use of certain chemicals in aquaculture in the region which is a helpful guide for fish farmers during their operations

Health Management of Milkfish *Chanos chanos* by Erlinda Cruz-Lacierda, Erish Estante, Evelyn Grace de Jesus-Ayson, Valeriano Corre Jr. A 36-page monograph on the occurrence, prevention and diagnosis of possible diseases in the culture of milkfish, from broodstock management to grow-out.

Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia: Challenges in Responsible Production of Aquatic Species. Proceedings of the International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia 2014 (RESA) by Maria Rowena Romana-Eguia, Fe D. Parado-Estapa, Nerissa Salayo, Ma. Junemie Hazel Lebata-Ramos (eds). A 371-page book that documents the proceedings of the *International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia* in 2014.

Proceedings of the International-Workshop on Mud Crab Aquaculture and Fisheries Management by Emilia Tobias-Quinitio, Fe D. Parado-Estapa, Y.C. Thampi Sam Raj, Anup Mandal (eds). A 128-page book that documents the proceedings of the *International-Workshop on Mud Crab Aquaculture and Fisheries Management* in April 2013.



Fairs and Exhibits

One of SEAFDEC/AQD's mandate is to disseminate and exchange information in aquaculture. In line with this, SEAFDEC/AQD participated in six events in 2015 to inform the general public and its stakeholders in particular of its research and extension activities. A total of 15,694 individuals from the private sector, academe, government and non-government agencies visited SEAFDEC/AQD's booths.

Aquatech 2015: 6th Aquaculture Expo & Convention; 28-29 May 2015; Tagaytay City, Philippines. Aquatech Philippines is an annual event organized to keep the industry updated on new aquaculture developments and technologies. SEAFDEC/AQD scientists Dr. Ma. Lourdes Aralar, Dr. Nerissa Salayo, and Dr. Maria Rowena Eguia gave seminars on giant freshwater prawn, abalone, and aquaculture

genetics, respectively. This event also gave SEAFDEC/AQD an opportunity to discuss with Senator Cynthia Villar, chair of the Senate Committee on Agriculture and Food, some issues on fisheries and aquaculture.

National Science and Technology Week; 24-28 July 2015; Pasay City, Philippines. An event organized by the Department of Science and Technology

that highlighted how science and technology (S&T) is infused in aqua-natural resource commodities to improve productivity, product quality, and profitability. SEAFDEC/AQD scientists Dr. Fe Dolores Estepa, Dr. Ma. Junemie Hazel Ramos, Dr. Emilia Qunitio, and Dr. Rolando Pakingking Jr. gave presentations during this event on nursery rearing of mud crab, oyster industry in the Philippines, soft-shell crab production and sanitary quality of oyster, respectively.

22nd AGRILINK/FOODLINK/AQUALINK; 15-17 October 2015; Pasay City, Philippines. SEAFDEC/AQD is a regular participant of the annual AgriLink fair. Information materials about the technologies on various commodities were distributed or sold and SEAFDEC/AQD technical resource persons provided free consultation on various aquaculture technologies.

10th Shrimp Congress; 10-13 November 2015; General Santos City, Philippines. This year's event was geared towards regaining the Philippines' position in shrimp export. During this event, SEAFDEC/AQD was able to showcase its aquaculture technologies and reach more aquaculture stakeholders in the Mindanao area.

1st Mud Crab Congress; 16-18 November 2015; Iloilo City, Philippines. An event organized by SEAFDEC/AQD and Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development and University of the Philippines Visayas. Through this event, SEAFDEC/AQD was able to distribute information materials about its technologies on various commodities.

2nd Iloilo Provincial Biodiversity and Watershed Week Celebration; 1-3 December 2015; Iloilo City, Philippines. A three-day event that includes series of lectures on the concepts of biodiversity and the status of biodiversity from the ridge to the reef in Iloilo Province. SEAFDEC/AQD scientist Dr. Teodora Bagarinao lectured on marine biodiversity and also participated in the poster exhibit.



Senator Cynthia Villar visits SEAFDEC/AQD booth at Aquatech 2015



A SEAFDEC/AQD technical staff demonstrates to school children how to culture oyster in individual pouches during the National Science and Technology Week



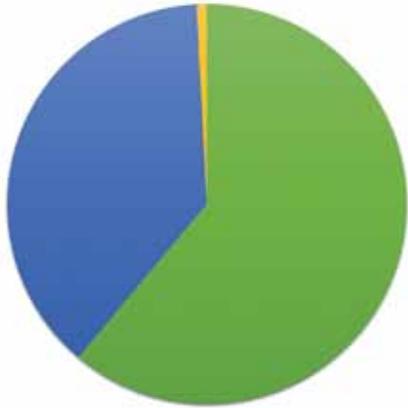
SEAFDEC/AQD senior staff entertain a guest during the 22nd AGRILINK/FOODLINK/AQUALINK

PHOTO COURTESY OF EQUIP INC / MLC ARALAR

PHOTOS BY IT TENDENCIA

Visitors

SEAFDEC/AQD had a total of 22,065 visitors to its four stations namely: Tigbauan Main Station and Dumangas Brackishwater Station in Iloilo, Igang Marine Station in Guimaras, and Binangonan Freshwater Station in Rizal. Most of the visitors this 2015 came from the academe and a few of them gave seminars about their studies.



- International, regional, and fisheries-related organizations (1%)
- Academe (61%)
- Private sector (38%)

Distribution of SEAFDEC/AQD's visitors in 2015



Mr. David Bright of the University of Sunshine Coast in Queensland, Australia gave a seminar titled "A study into parental assignment of the communal spawning protogynous hermaphrodite giant grouper *Epinephelus lanceolatus*" on 10 December 2015.



PHOTO BY GK FAIGANI

APEC delegates during their tour at SEAFDEC/AQD's integrated marine fish hatchery where newly harvested milkfish fry are distributed into basins before packing and transport



PHOTO BY JIM DELA CRUZ

Philippine Society of Youth Science Clubs (PSYSC) members explore SEAFDEC/AQD's FishWorld museum



PHOTO BY EV ANTONILINO

United States Department of Agriculture (USDA) Foreign Agricultural Service guests look at an abalone broodstock reared in SEAFDEC/AQD



PHOTOS BY RH LEDESMA

Laboratory and diagnostic services at SEAFDEC/AQD

Hatchery and Grow-out Production

Milkfish topped SEAFDEC/AQD’s hatchery production this 2015 producing more than 100 million larvae and about nine million fry (see Table 2).

For grow-out, SEAFDEC/AQD produced about 18 tons market-sized commodities from research activities (see Table 3). The bulk of the production, that is about 13 tons, was from studies on milkfish. In addition, SEAFDEC/AQD was able to produce 4,366 pieces of soft-shell crabs.

Table 2. SEAFDEC/AQD’s hatchery production in 2015

Commodity	Quantity (pcs)	
	larvae	fry/fingerlings
Milkfish	143,414,562	9,252,150
Grouper	52,310,959	15,801
Rabbitfish	15,701,869	338,815
Sea bass	14,271,619	92,800
Snapper	2,045,068	27,209
Pompano	1,585,367	425,890
Bighead carp	-	1,879,310
Tilapia	-	844,174
	megalopae/crab instar	juveniles
Mud crab	646,050	218,195
Abalone		41,370
	postlarvae/juveniles	
Giant freshwater prawn		61,842

Table 3. Market-sized commodities produced by SEAFDEC/AQD in 2015

Commodity	Quantity (kg)
Milkfish	13,234
Pompano	1,943
Rabbitfish	1,710
Grouper	709
Snapper	221
Sea bass	78
Bighead carp	155
Tilapia	134
Silver therapon	5
Giant freshwater prawn	3
Shrimp	242
Abalone	22

Larval Food Production

The *Larval Food Laboratory* produced 50,779 liters of microalgal and rotifer starters and 12.8 kg (wet weight) of *Artemia* biomass to support the research and production activities of SEAFDEC/AQD.

The laboratory also sold 4,202 liters of liquid microalgal/rotifer starters (see Table 3 for the phytoplankton species make up), 17 kilograms of concentrated microalgal paste, and 88 tube cultures. Pre-mixed fertilizers and culture sold comprised of 77.2 liters of TMRL, 139.6 liters of F medium and 12.6 liters of Conwy medium.

Earnings amounted to PHP 317,809.72. A total of 100 clients comprising of the private sector (43% both local and foreign), academe (52%), and government institutions (5%) were served.



Table 4. Phytoplankton species make up of liquid microalgal and rotifer starters

Species	Percent (%)
<i>Skeletonema tropicum</i>	17.42
<i>Nanochlorum</i> sp.	49.31
<i>Chaetoceros calcitrans</i>	20.35
<i>Brachionus rotundiformis</i>	1.07
<i>Tetraselmis tetraathele</i>	1.67
<i>Chlorella sorokiniana</i>	1.64
<i>Navicula ramossissima</i>	1.90
<i>Thalassiosira</i> sp.	0.31
<i>Isochrysis galbana</i>	6.31
<i>Chaetoceros muelleri</i>	0.01

Feed Mill Production

SEAFDEC/AQD's feed mill produced more than 75 tons of various feeds (see Table 4) with 15.3% going to the private sector (mostly for milkfish broodstock) and the rest to the studies conducted by the Department. The feed mill's income this 2015 amounted to PHP 1,061,115.87.



Table 5. Aquafeed produced at the SEAFDEC/AQD Feed Mill

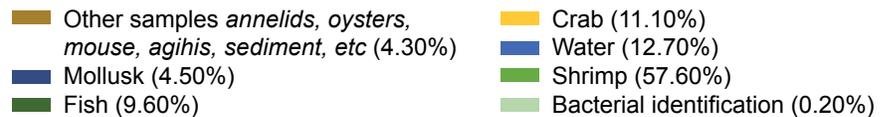
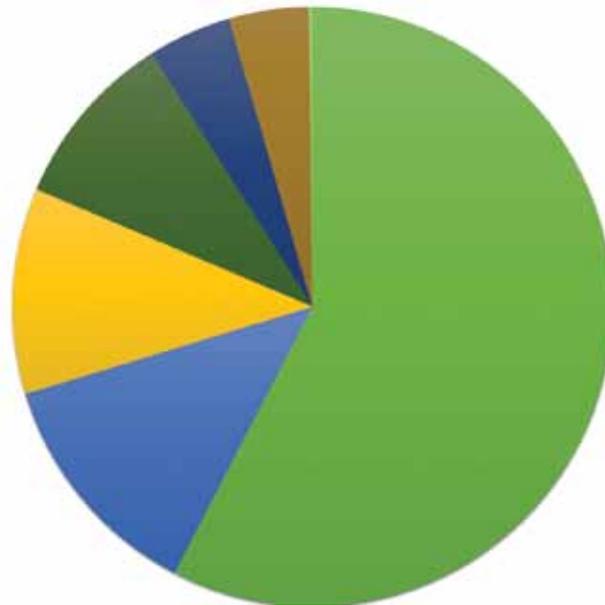
Feed Type	Volume (kg)		
	SEAFDEC/AQD	Private Sector	Total
Milkfish			
• Broodstock	8,049	9,260	17,309
• Larval	113	32	145
• Grow-out	34,344	117	34,461
Grouper			
• Broodstock	225		225
• Larval	411		411
• Grow-out	3,135	50	3,185
Siganid			
• Broodstock	650		650
• Grow-out	2,960		2,960
Sea bass broodstock	1,200		1,200
Tilapia broodstock	447	173	620
Catfish broodstock	50		50
Mud crab	229	1,599	1,828
Shrimp	2,133	140	2,273
Abalone	32	6	38
High-value	9,560		9,560
Feed ingredients	197	110	307
TOTAL	63,735	11,487	75,222

Diagnostic Services

The Fish Health Laboratory examined a total of 552 diagnostic cases wherein almost 60% of the cases examined were on shrimp.

The 10 viral diseases diagnosed by PCR were: WSSV, IHNV, AHPND/EMS, and VNN, IMNV, TSV, YHV/GAV, MBV, RSIV, and KHV.

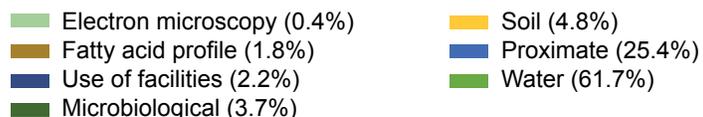
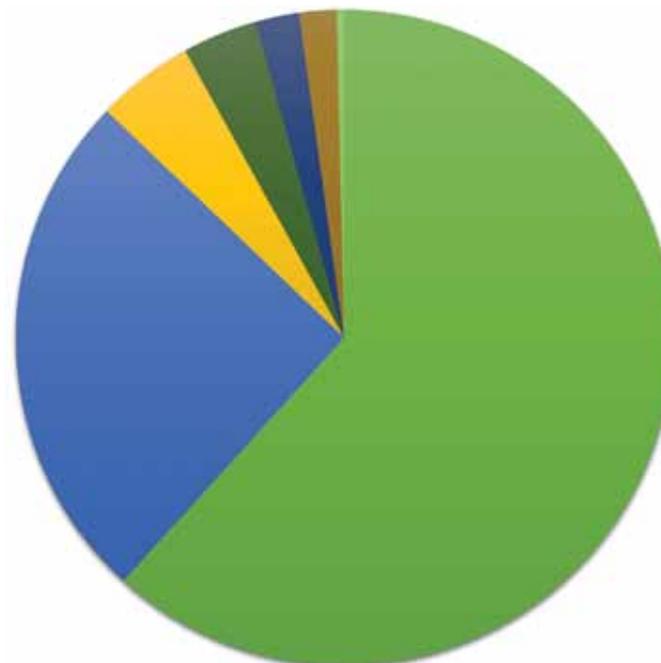
SEAFDEC/AQD also accepted samples for bacterial count (327 samples), bacterial identification (11 samples), larval monitoring and MBV detection using Malachite Green staining (58 samples), parasite detection (12 samples) and histological samples for research and diseases diagnosis (1,667 slides for 2,042 samples). Fish Health Laboratory's income for this year amounted to PhP 1,298,414.19.



Diagnostic cases examined by the Fish Health Laboratory in 2015

Laboratory Services

SEAFDEC/AQD's *Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT)*, accepted for analysis a total of 3,967 samples (or 4,700 determinations) the bulk of which came from SEAFDEC/AQD research studies and a few from the private sector or the academe. Some 1,009 of these samples were for proximate analyses for crude protein, crude fat, crude fiber, calcium, phosphorus, moisture, and ash; 73 for fatty acid profile; 2,448 for water analyses for pH, alkalinity, ammonia-N, ammonium-N, chlorophyll, dissolved oxygen, nitrite, nitrate, phosphate, sulfide, total hardness, total suspended solids, and pesticide residues; 191 for soil analyses for pH, organic matter, available Fe/S/P, and CNS; 146 microbiological analyses for APC, *Salmonella*, *Shigella*, *Staphylococcus aureus*, coliform, *Escherichia coli*, *Vibrio*, yeast & mold, and water potability; and 14 for scanning & transmission electron microscopy. LFAAT had a total income of PhP 817,774.08.



Samples accepted for various analyses at SEAFDEC/AQD's LFAAT



PHOTOS BY IT TENDENCIA

An organization and policy orientation for SEAFDEC/AQD staff

Staff Development



(L-R) SEAFDEC/AQD Scientist Dr. Mae Catacutan, Associate Scientist Dr. Frolan Aya and Associate Researcher Ms. Sheryll Avanceña give their presentation at ICAI 2015

In 2015, SEAFDEC/AQD supported the attendance of its research and information personnel to various meetings and conferences, where they presented papers or participated in the event. Some staff also received assistance for their study or training.

Engage in studies on seed production and release for stock enhancement of seahorses under the framework of Japan Society for Promotion of Science- RONPAKU Program; 31 May-9 July 2015 at Hokkaido University, Japan

Pre-CONSAL (Congress of Southeast Asian Librarians) Workshop: Leadership Workshop for Young Promising Librarians to Build Stronger Library Associations in ASEAN Countries; 8-9 June 2015 in Bangkok, Thailand

16th Congress of Southeast Asian Librarians (CONSAL XVI); 10-13 June 2015 in Bangkok, Thailand

International Symposium on Genetics in Aquaculture XII (ISGA XII); 21-27 June 2015 in Santiago de Campostela, Spain

Training Course on Economic Valuation of Environmental and Natural Resources; 3-7 August 2015 in Los Baños, Laguna

41st IAMSILIC (International Association of Marine Science Libraries and Information Centers) Annual Conference, 16th EURASLIC Biennial Meeting; 7-11 September 2015 in Rome, Italy

Short-term training/visit in Japan in line with SEAFDEC Assistance Project under Marino Forum 21; 21 September-17 October 2015 in Japan

ASFA (Aquatic Sciences and Fisheries Abstracts) Board Meeting; 5-9 October 2015 in Nova Scotia, Canada

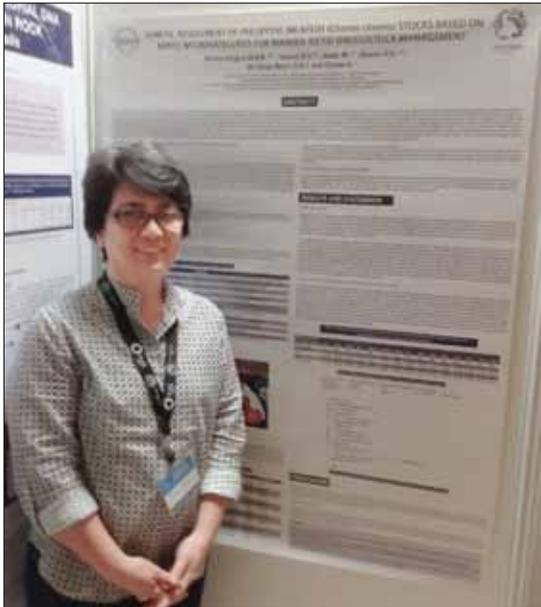
9th International Abalone Symposium; 5-10 October 2015 in Yeosu, Korea

6th International Oyster Symposium; 21-23 October 2015 in Massachusetts, USA

International Conference of Aquaculture in Indonesia (ICAI 2015); 29-31 October 2015 in Jakarta, Indonesia

10th National Shrimp Congress; 11-13 November 2015 in General Santos City, Philippines

Seminar on Environmental, Health and Safety: Regulation Update and Compliance; 12-13 November 2015 in Manila, Philippines



SEAFDEC/AQD scientist Dr. Maria Rowena Eguia beside her poster presented during the *International Symposium on Genetics in Aquaculture XII*

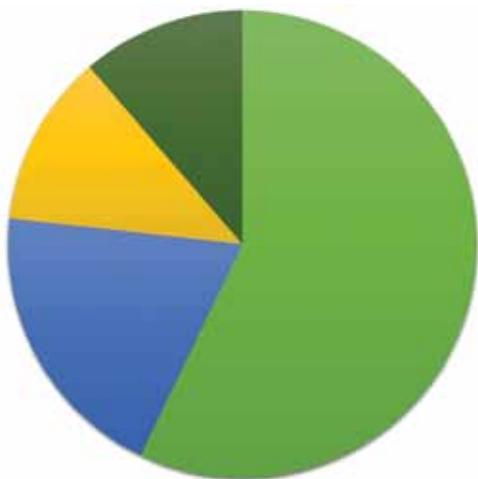


SEAFDEC/AQD's senior information assistants Mr. Superio and Mr. Alayon at the IAMSILIC annual conference in Rome

PHOTO COURTESY OF MRR EGUIA/BALAYON

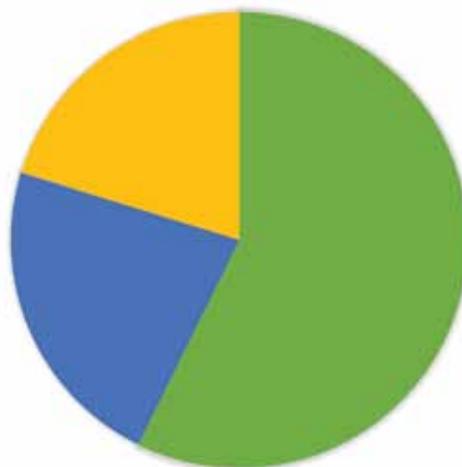
Personnel Distribution

SEAFDEC/AQD had a total personnel complement of 168 (regular employees-93, fixed-term employees-75) as of 31 December 2015. Out of the total personnel; 12% have doctorate degree, 20% have master's degree, and 57% are bachelor's degree holders.



SEAFDEC/AQD's personnel distribution per educational attainment

- Bachelor's degree (57%)
- Master's degree (20%)
- Doctorate degree (12%)
- Non-bachelor degree (11%)



Educational attainment of the research team of SEAFDEC/AQD

Finance

The Government of the Philippines (as host of SEAFDEC/AQD) through the Department of Foreign Affairs' International Commitment Fund contributed about 70% of the total funds of SEAFDEC/AQD. External sources of funds were also available for SEAFDEC/AQD's research programs and projects. Almost 60% of the Department's expenditures go to research programs followed by general administrative and non-project expenses, information programs, and training programs; respectively.

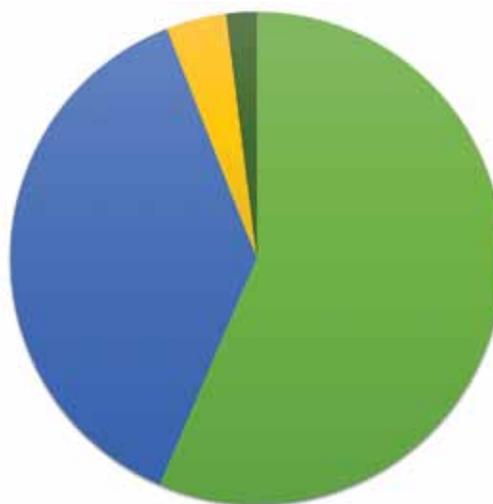
Table 6. SEAFDEC/AQD's Sources of Funds in 2015

	US Dollar '000
Government of the Philippines	3,612
External Grants	975
Internally-generated Income	505
TOTAL	5,092



- Internally-generated income (10%)
- External grants (19%)
- Government of the Philippines (71%)

SEAFDEC/AQD's sources of funds



- Training Programs (2%)
- Information Programs (4%)
- General Administrative and Non-project Expenses (38%)
- Research Programs (56%)

Expenditures of SEAFDEC/AQD in 2015



PHOTO BY JIM DELA CRUZ

SEAFDEC/AQD Chief Dr. Felix Ayson discusses the accomplishments for 2015 and plans for 2016 during a General Assembly

Table 7. Statement of Financial Position

STATEMENT OF FINANCIAL POSITION (US Dollar '000)		
	As of 31 Dec. 2015	As of 31 Dec. 2014
ASSETS		
CURRENT ASSETS		
Cash and Cash Equivalents	1,941	2,545
Accounts Receivables	484	658
Materials and Supplies	71	55
Other Current Assets	1	2
Total Current Assets	2,497	3,260
NON-CURRENT ASSETS		
Cash Investments	-	-
Other non-current assets	309	401
Total Non-current Assets	309	401
TOTAL ASSETS	2,806	3,661
LIABILITIES		
CURRENT LIABILITIES		
Accounts Payable	983	969
Funds Held-in Trust	289	393
TOTAL LIABILITIES	1,272	1,362
NET ASSETS		
Designated	1,534	2,299
Undesignated	-	-
Unrealized Gain on Available for Sale Financial Assets		14
TOTAL NET ASSETS	1,534	2,299
TOTAL LIABILITIES AND NET ASSETS	2,806	3,661

STATEMENT OF REVENUES & EXPENDITURES (US Dollar '000)		
	Period ending 31 Dec. 2015	Period ending 31 Dec. 2014
REVENUES		
Contributions/Grants	4,587	5,232
Other Income	505	623
TOTAL REVENUE	5,092	5,855
EXPENDITURES		
Research Programs	3,279	3,988
Training Programs	136	166
Information Programs	206	389
General Administrative and Non-project Expenses	2,106	1,441
TOTAL EXPENDITURES	5,727	5,984
BALANCE	(635)	(129)

SEAFDEC/AQD Officers in 2015

<i>AQD Chief</i>	Dr. Felix Ayson
<i>Deputy Chief</i>	Dr. Takuro Shibuno
<i>Head, RD</i>	Dr. Evelyn Grace Ayson
<i>Head, TVDD</i>	Dr. Fe Dolores Estepa
<i>Head, TID</i>	Dr. Ma. Junemie Hazel Ramos
<i>Head, AFD</i>	Ms. Kaylin Corre
<i>OIC, BFS</i>	Dr. Frolan Aya
<i>Head, DBS</i>	Dr. Emilia Qunitio
<i>OIC, IMS</i>	Mr. Mateo Paquito Yap
<i>OIC, Manila Office</i>	Dr. Maria Rowena Eguia

Program Leaders

<i>Producing quality seed for sustainable aquaculture</i>	Dr. Maria Rowena Eguia
<i>Promoting healthy and wholesome aquaculture</i>	Dr. Myrna Teruel and Dr. Rolando Pakingking Jr.
<i>Maintaining environmental integrity through responsible aquaculture</i>	Dr. Maria Lourdes Aralar
<i>Meeting socioeconomic challenges in aquaculture</i>	Dr. Nerissa Salayo
<i>Regional programs</i>	Dr. Takuro Shibuno

Section Heads/OIC

[RD]	
<i>Breeding and seed production</i>	Ms. Milagros dela Peña
<i>Fish health</i>	Dr. Rolando Pakingking Jr.
<i>Nutrition and feed development</i>	Dr. Mae Catacutan
<i>Farming systems and ecology</i>	Ms. Maria Rovilla Luhan
<i>Socioeconomics</i>	Dr. Nerissa Salayo
[TVDD]	
<i>Technology verification</i>	Dr. Myrna Teruel
<i>Demonstration and packaging</i>	Dr. Veronica Alava
[TID]	
<i>Training</i>	Dr. Ma. Junemie Hazel Ramos
<i>Development communication</i>	Mr. Jesus Manolo Almendras
<i>Library and databanking services</i>	Mr. Stephen Alayon
[AFD]	
<i>Engineering</i>	Engr. Arnel Gelfero
<i>Human resources management</i>	Atty. Gina Gomez
<i>Budget-cashiering</i>	Ms. Jiji Rillo
<i>Accounting</i>	Ms. Jasmine Gelfero

RD, Research Division
TVDD, Technology Verification and Demonstration Division
TID, Training and Information Division
AFD, Administration and Finance Division
BFS, Binangonan Freshwater Station
DBS, Dumangas Brackishwater Station
IMS, Igang Marine Station



www.seafdec.org.ph

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 Viet Nam.

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

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

- The **Training Department (TD)** in Samut Prakan, Thailand (1967) for training in marine capture fisheries
- The **Marine Fisheries Research Department (MFRD)** in Singapore (1967) for post-harvest technologies
- The **Aquaculture Department (AQD)** in Tigbauan, Iloilo, Philippines (1973) for aquaculture research and development
- The **Marine Fishery Resources Development and Management Department (MFRDMD)** in Kuala Terengganu, Malaysia (1992) for the development and management of fishery resources in the exclusive economic zones of SEAFDEC member countries; and
- The **Inland Fishery Resources Development and Management Department (IFRDMD)** in Palembang, Indonesia (2014) for sustainable development and management of inland capture fisheries in the Southeast Asian region.

AQD is mandated to:

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

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

