



Southeast Asian Fisheries Development Center  
AQUACULTURE DEPARTMENT  
ANNUAL REPORT

SEAFDEC/AQD  
**HIGHLIGHTS**  
**2016**





SEAFDEC/AQD's Tigbauan Main Station

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## 2016 SEAFDEC/AQD HIGHLIGHTS

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Front cover: One of many harvest-size sandfish  
within SEAFDEC/AQD's sea ranch site at  
Molocaboc Island, Sagay. (photo by JP  
Altamirano)

Photo on back cover: A local diver collects  
samples of sandfish from SEAFDEC/AQD's  
sea ranch for the monthly monitoring of  
stocks. (photo by JP Altamirano)

# Message



SEAFDEC/AQD has an enormous task in terms of steering aquaculture development towards sustainability, food security, and improvement of livelihood. We continued to work this year with our stakeholders to translate this mission into reality.

This 2016, SEAFDEC/AQD gave special attention towards mitigating the effects of the Early Mortality Syndrome or Acute Hepatopancreatic

Necrosis Disease and other transboundary diseases affecting shrimp farms worldwide. In February this year, we organized a Regional Technical Consultation that brought together delegates from member countries and international organizations to define research and policy directions. The consultation renewed the commitment of ASEAN Member States, regional and international organizations, and our other partners to more closely work together towards improved aquatic animal health, especially in addressing present and emerging diseases.

Our efforts to alleviate poverty in coastal communities has shown positive developments, particularly in our Community-Based Resource Enhancement Project at Molocaboc Island where we have stocked hatchery-bred abalone and sandfish in the past years. The

local fisherfolk have started to harvest and sell abalone recruits from the released abalones. Gleaners have likewise reported spill-overs of both abalone and sandfish outside the original release site. The sandfish are expected to also reach harvestable size very soon and further benefit the local economy.

After 43 years, SEAFDEC Aquaculture Department still has much more to offer the Southeast Asian Region and the world. As we strengthen our ties with our partners and strive to be more responsive to needs of our varied stakeholders, we will continue to make discoveries and innovations for truly competitive and sustainable aquaculture.

**Chihaya Nakayasu, PhD.**  
Acting Chief, SEAFDEC/AQD



SEAFDEC/AQD's Binangonan Freshwater Station

# Major Awards in 2016

## Promoter of Mud Crab Aquaculture



The Philippine Aquaculture Society and the Society of Aquaculture Engineers awarded AQD Scientist Dr. Emilia Quinitio (middle) as Promoter of Mangrove Crab Aquaculture in the Philippines for her outstanding leadership and devoted service last 7 December 2016 in Dagupan City. Photo by Asian Fisheries Academy.

## Chemical Research Award



Dr. Relicardo Coloso (middle), a scientist at SEAFDEC/AQD, was given an award for his "contributions to Chemical Research" by the Philippine Federation of Chemistry Societies (PFCS) during the "31st Philippine Chemistry Congress" held in Iloilo City from 13 to 15 April 2016. Photo by PFCS.

## Freshwater Biodiversity Award



Dr. Maria Lourdes Cuvin-Aralar, a SEAFDEC/AQD scientist, was given an award for her contributions to freshwater biodiversity and ecosystems science during the 1st Philippine

Symposium on Freshwater Biodiversity and Ecosystems held at the University of Santo Tomas, Manila, Philippines from 7 to 10 June 2016.

## Outstanding Academic Library



The SEAFDEC/AQD Library was given the 2015 Outstanding Academic/Research Library Award, given by the Philippine Association of Academic and Research Librarians, for its contributions to academic and research librarianship; outstanding leadership in national and regional library development; as well as commitment to information networking and linkages.



SEAFDEC/AQD's Igang Marine Station

# New Collaborations

## Academe

Partner Institution	Nature of collaboration	Period
<b>Western Philippines University</b> (San Juan, Aborlan, Palawan)	On-the-Job Training Program	27 Jan. 2016 - 26 Jan. 2021
<b>Northern Mindanao School of Fisheries</b> (Buenavista, Agusan del Norte)	On-the-Job Training Program	2 Sept. 2016 - 1 Sept 2017
<b>Southern Philippines Agri-Business and Marine and Aquatic School of Technology</b> (Malita, Davao Occidental)	Technical assistance for hatchery, nursery and grow-out operations of abalone culture	17 Oct. 2016 - 31 Dec. 2016
<b>Pukyong National University</b> (Republic of Korea)	On-the-Job Training Program	4 Jan. 2016 - 19 Feb. 2016

## Government and Non-Government Organizations

Partner Institution	Nature of collaboration	Period
<b>Japan International Research Center for Agricultural Sciences</b> (Ibaraki, Japan)	Implementation of research projects	14 July 2016 - 31 Mar. 2021
<b>Bureau of Fisheries and Aquatic Resources</b> (Diliman, Quezon City)	Training Course on Oyster Seed Production, Nursery and Grow-out	26 Sept. 2016 - 29 Oct. 2016
<b>Deutsche Gesellschaft fur Internationale Zusammenarbeit GmbH</b> (Makati, Metro Manila)	Providing of resource person on hatchery technology of mudcrab	1 Nov. 2016 - 20 Nov. 2016
<b>INSOL Development Foundation Inc.</b> (Pasig, Metro Manila)	Technical assistance in the use of seaweed extract for fertilization of cacao	
<b>Network of Aquaculture Centres in Asia-Pacific</b> (Bangkok, Thailand)	Conduct of research, training and extension programs and exchange of experts	

## Private Sector

Partner Institution	Nature of collaboration	Period
<b>Mr. Hernan D. Biron Sr.</b> (Barotac Nuevo, Iloilo)	Testing of cost-effective artificial feed for mudcrab	1 Jan. 2016 - 31 Dec. 2016
<b>Emelinda Abian</b> (Concepcion, Iloilo)	On-the-Job Training Program	
<b>Cosmic Technologies, Inc.</b> (Malate, Manila); <b>Brgy. Council of Pipindan</b> (Binangonan, Rizal); <b>Samahan ng mga Mag-uulang sa Pipindan</b> (Binangonan, Rizal)	Technical assistance to the fisherfolks and assist the fisher folks in marketing their products/harvest	18 Nov. 2016 - 17 Dec. 2019
<b>Jessyl Jane Olivares</b> (Nueva Valencia, Guimaras)	Development of the nursery technology of the blue swimming crab in a pond	15 Jul 2016 - 14 June 2017

# 2016 Research and Development Programs

## THEMATIC PROGRAMS

Study Title		Main Proponent	Collaborating Partners
<b>Quality Seed for Sustainable Aquaculture</b>			
1	Effects of depth and temperature on the mating behavior and reproductive performance of black tiger shrimp ( <i>Penaeus monodon</i> )	EG Estante	
2	Refinement of feeding techniques for sustainable mass production of polychaete <i>Marphysa mossambica</i> in outdoor tanks	MAE Mandario	
3	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
4	Domestication of silver therapon ( <i>Leiopotherapon plumbeus</i> ) (Perciformes: Terapontidae): I. Nutritional evaluation of wild-sourced and hatchery-bred stocks for feed development; II. Reproductive performance of wild and hatchery-bred silver therapon	FA Aya	
5	Refinement of sandfish hatchery techniques	FG Ayson	
6	Improvement of the performance of captive <i>Penaeus monodon</i>	FDP Estepa	DOST-PCAARRD
7	Refinement of abalone culture techniques to enhance growth, meat quality and maturation <b>Subtitle 1:</b> 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> ; <b>Subtitle 2:</b> Triploid induction of <i>Haliotis asinina</i> ;	MR de la Peña	DOST-PCAARRD
8	Growth and reproductive performance of the minute monogont rotifer, <i>Proales similis</i> de Beauchamp, reared on locally available microalgal strains	AV Franco	
9	Developing transport techniques for milkfish, <i>Chanos chanos</i> , juveniles	JIL Aquino	
10	Increasing abalone juvenile production through improved hatchery culture techniques. <b>Subtitle 1:</b> Use of chemical cues (positive ions, algal extracts) to improve settlement rate; <b>Subtitle 2:</b> Improve culture efficiency with the use of new tank design, orientation of plates and re-circulating system; <b>Subtitle 3:</b> Use of anaesthetic agents as muscle relaxant for efficient sorting and harvesting of abalone juveniles	MR de la Peña	DOST-PCAARRD
11	Hatchery and nursery operation for blue swimming crab, <i>Portunus pelagicus</i> : Project 2 - Development of the nursery technology for the blue swimming crab, <i>Portunus pelagicus</i>	FDP Estepa	DOST-PCAARRD

Study Title		Main Proponent	Collaborating Partners
12	Studies on seed production and release of seahorses for stock enhancement (PhD Dissertation)	SMB Ursua	JSPS-Ronpaku
13	Improvement of larval rearing protocol for <i>Portunus pelagicus</i>	ET Qunitio	DOST-PCAARRD
14	Refinement of hatchery techniques for the donkey's ear abalone <i>Haliotis asinina</i> <b>Substudy 1:</b> Improvement of fecundity and seed quality of breeders recently acquired from the wild; <b>Substudy 2:</b> Evaluation of genetic stocks for selective breeding in abalone; <b>Substudy 3:</b> Increase survival rate of veliger larvae through improvement of harvest and incubation protocol	ET Qunitio	DOST-PCAARRD
15	Development of diet to improve broodstock breeding performance and larval quality of sandfish <i>Holothuria scabra</i>	JB Biñas	
16	Nursery rearing techniques for seed production of <i>Kappaphycus</i> "seedlings"	MRJ Luhan	
17	Promotion of livelihood opportunities in freshwater aquaculture for peri-urban communities I. Small-scale tilapia and giant freshwater prawn hatchery seedstock production; II. Skills training on freshwater aquaculture and ancillary industries	MRR Eguia	
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	Large-scale production of donkey's ear abalone, <i>Haliotis asinina</i> juveniles	D Catedral (NC Bayona)	
<b>Healthy and Wholesome Aquaculture</b>			
21	Effect of thraustochytrid on reproductive performance of hatchery-bred abalone, <i>Haliotis asinina</i>	RBS Taan	
22	Evaluation of enriched <i>Ulva lactuca</i> and <i>Gracilaria bailinae</i> as feed ingredients in abalone <i>Haliotis asinina</i> diet	RBS Taan	
23	Quantitative amino acid requirements of juvenile Asian sea bass ( <i>Lates calcarifer</i> Bloch): Requirements for leucine, isoleucine and histidine	RMA Cabrera	
24	Evaluation of distillers dried grain with solubles (DDGS) as protein ingredient of diets for milkfish cultured in floating net cages	RE Mamauag	
25	Evaluation of milkfish by-product hydrolysate as ingredient in marine finfish diets	RE Mamauag	
26	Feed development for the golden pompano, <i>Trachinotus blochii</i>	MR Catacutan	
27	Use of commercial probiotics (PRO W, PRO 2) and disinfectant (PUR) to control acute hepatopancreatic necrosis disease (AHPND) and luminiscent vibriosis in <i>Penaeus vannamei</i>	LD de la Peña	INVE

Study Title		Main Proponent	Collaborating Partners
28	Effects of Poly- $\beta$ -hydroxybutyrate-accumulating <i>Bacillus</i> species on the water quality and thermal stress response of <i>Penaeus monodon</i> post larvae during culture	JLQ Laranja Jr.	
29	Prevention and mitigation of diseases in mud crab	EA Tendencia	DOST-PCAARRD
30	Establishment of Philippine shrimp pathogen bio-bank and online biosurveillance information resource	EC Amar	DOST-PCAARRD
31	Establishment of sanitary quality of oysters and their culture environments	RV Pakingking Jr.	DOST-PCAARRD
32	Development of shrimp pathogen diagnostic tools using nested PCR and lateral flow strip biosensors coupled with a mobile app and cloud-based information management (Project 3)	LD de la Peña	DOST-PCAARRD
33	Performance of hatchery-bred <i>Penaeus indicus</i> in grow out	SS Avanceña	
34	Commercialization of soft-shell crab production	JIL Aquino	
35	Improving pond production of <i>Gracilariopsis heteroclada</i> Zhang & Xia by fertilization of the starting plant materials	SS Avanceña	
36	Semi-intensive grow-out production of grouper <i>E. fuscoguttatus</i> and <i>E. coioides</i> fed SEAFDEC/AQD phased-diet in brackishwater ponds	EB Coniza (MR Catacutan)	
<b>Maintaining Environmental Integrity through Responsible Aquaculture</b>			
37	Giant freshwater prawn culture in lake-based cages: Strategies to improve production through stock manipulation and management	MLC Aralar	
38	Culture of <i>Caulerpa</i>	MRJ Luhan	
39	Giant freshwater prawn culture in biofloc system	MLC Aralar	
40	Grow-out of abalone in small islands and/or community	MJHL Ramos	DOST-PCAARRD
41	Refinement of existing oyster grow-out techniques	MJHL Ramos	DOST-PCAARRD
42	Culture trial for sandfish <i>Holothuria scabra</i> in ponds and sea ranch	JP Altamirano	ACIAR
43	<i>Kappaphycus alvarezii</i> farming and its use as fertilizer for cacao tree	HT Sollesta	INSOL
<b>Meeting Social and Economic Challenges in Aquaculture</b>			
44	Economic benefits and losses in seaweed farming in Guimaras, Philippines due to some climate change indicators	RJG Castel	
45	Coastal area capability development through community-based stock enhancement in New Washington, Aklan, Philippines	JP Altamirano	RIHN

## REGIONAL PROGRAMS (GOJ-TRUST FUND)

<b>Reinforcement and optimization of fish health management and effective dissemination in the Southeast Asian Region</b>			
46	Enhancement of vaccine efficacy for the prevention of viral nervous necrosis in high value marine fish	RV Pakingking Jr.	GOJ-TF
47	Establishment of protective measures against persistent and emerging parasitic diseases of tropical fish	GE Pagador	GOJ-TF



Study Title	Main Proponent	Collaborating Partners
48	Application of adjuvants, carriers and RNAi technology to enhance the antiviral immune response of shrimp to WSSV	EC Amar GOJ-TF
49	Epidemiology of the acute hepatopancreatic necrosis disease (AHPND) in <i>Penaeus monodon</i>	EA Tendencia GOJ-TF
50	Development and acceleration of rapid and effective fish and shrimp health management. <b>Subtitle:</b> Establishment of threshold infection levels of WSSV, VNN, and AHPND in the shrimp	LD de la Peña GOJ-TF
<b>Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources</b>		
51	Responsible aquaculture through aquasilviculture	EA Tendencia GOJ-TF
52	Use of plant-based protein sources in tilapia feeds for improved production traits	FA Aya GOJ-TF
53	Promotion of resource enhancement of seahorses	SMB Ursua GOJ-TF
54	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 GOJ-TF

## SPECIAL PROJECTS

55	Development of ice-ice resistant strains of <i>Kappaphycus</i> and technology for reduction of epiphytes	MRJ Luhan ACIAR
56	On-farm strategies for promoting IMTA through Sustainable Livelihood Approach (SLA) in Guimaras, Philippines	ND Salayo/ M Kodama JIRCAS
57	Outplanting of <i>Kappaphycus</i> propagules in the province of Palawan	MRJ Luhan LGU Palawan

# Quality Seed for Sustainable Aquaculture

Success in aquaculture production is primarily dependent on the availability of good quality and steady supply of seedstock. This can be achieved through genetic manipulation and application of appropriate culture management.



Crab instars produced by first generation crabs as part of ongoing efforts to produce genetically improved mangrove crabs

—  
Alternative sources of protein  
for feeds identified

—  
Taurine found to be essential  
during early stages of  
pompano growth

—  
Three farms successfully  
adopted improved soft-shell  
crab production technology

—  
Indian almond leaf extracts  
shown to provide  
antibiotic-like protection to  
early crab stages

## OBJECTIVES

Generate, verify and promote technologies to ensure the sustainable production of quality seed stock either for aquaculture or stock enhancement

- Develop good quality broodstock for both traditional and emerging species
- Improve seedstock production through the refinement of hatchery and nursery management methods
- Develop schemes for the production, management, maintenance and dissemination of genetically selected and improved stocks
- Produce sufficient seedstock through economically viable seed production systems.

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## Development of good quality broodstock

Genetic and nutritional intervention has been developed to enhance growth, survival, disease resistance and stress tolerance. Technologies that have been developed in the laboratory are now packaged and applied.

In aquaculture, improved seedstock is preferred to ensure a better harvest. For stock enhancement, seedstock 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.

To achieve the main objective of developing and managing quality broodstock for use in either commercial fish farming and/or stock repopulation, molecular markers are used to aid in determining the genetic quality of hatchery stocks. This, apart from information on reproductive

efficiency and production traits, help formulate broodstock management protocols.

Molecular markers were used for genetic characterization in stocks of several important aquaculture species such as the donkey's ear abalone (*Haliotis asinina*), oyster (*Crassostrea irredalei*) and the mangrove crab (*Scylla serrata*). The same was done for the indigenous seahorse, *Hippocampus* spp., for stock enhancement purposes.

### Abalone

Six microsatellite (ms) DNA markers have been developed to characterize the existing SEAFDEC/AQD abalone hatchery stock (originally from Concepcion, Iloilo) and several Philippine abalone stocks obtained from the wild (Pangasinan, Masbate, Palawan, Zamboanga del Sur, Sagay, Cebu, Zamboanga del

Norte) for broodstock evaluation. Spawning batches (minimum five families per stock) were also set up for reproductive efficiency and production trait evaluation. Molecular marker variation data is currently being analysed and will later be correlated with breeding performance. From the reproductive efficiency comparison, hatchery-bred abalone stocks had the highest number of eggs as well as the number of eggs per gram body weight (BW) female. Among the wild stocks, Zamboanga del Sur broodstock had the highest fecundity while the Pangasinan broodstock produced the most number of eggs/g BW female. For larval survival, stocks from Cebu had the highest rate. These information and those obtained from the molecular marker variation assessment shall be used in the formulation of a broodstock management and selective breeding scheme for the donkey's ear abalone.

### Oyster

Molecular genetic characterization of potential oyster broodstock from wild sources is currently being done by the University of the Philippines Visayas as part of the National Oyster R&D Program led by SEAFDEC/AQD with funds from the Philippine Department of Science and Technology. Apart from the genetic screening of potential good quality oyster (*Crassostrea irredalei*) broodstock from wild populations, protocols for broodstock management and conditioning are being developed to maximize seedstock production in the hatchery. It has been noted



SEAFDEC/AQD abalone (*Haliotis asinina*) hatchery stock are being characterized along with wild stocks from different Philippine provinces for broodstock evaluation

that a 30°C rearing temperature improved oyster broodstock sexual maturity from an 82% spent broodstock status to a 70% sexually mature oyster stock. The highest broodstock survival (60%) was noted in conditioning tanks that held stocks in ambient water temperature.

### Mangrove Crab

Selective breeding to improve growth and disease resistance is being pursued for the mangrove crab *Scylla serrata*. Six working msDNA markers are being used in the on-going mass selection project to keep track of the impact of domestication and selective breeding on the farmed stocks that are being improved for growth, survival and WSSV disease resistance. Stocks from Surigao del Sur and Camarines Sur are being used in selective breeding hence F<sub>1</sub> stocks have been produced and are currently being on-grown to mature, adult sizes. Prior to these, the same batches were stocked to evaluate growth in three-size groups of juveniles from Camarines and Surigao. The specific growth rate of crab juveniles produced from Surigao broodstock was higher in small-size crabs than in the normal growing (medium) and big-size crabs after 192 days of culture. The specific growth rate was comparable in medium and big crabs.

### Tiger Shrimp

In the tiger shrimp *Penaeus monodon*, the type of holding system and different water depths/temperature gradients, were assessed to identify the suitable environment that will have a positive effect on the mating behavior and mating success of wild and captive tiger shrimp



Adult mangrove crabs (*Scylla serrata*) selectively harvested to be used as broodstock

broodstock. Those reared in the tanks resulted in maturation up to Stage 2, but none matured in the pens. One tank given diet with taurine reached stage 3 and spawned, but the larvae died at the mysis stage. The observed maturation and spawning in the experiments were low which may be due to the extremely high temperatures at that time. High temperatures also seem to have hampered growth of the shrimp that are now being cultured to broodstock size.

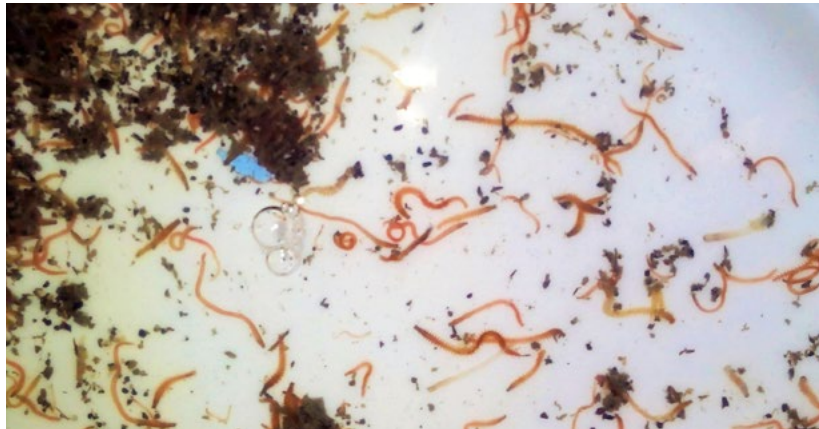
### Marine annelid

Nutritional approaches have also been investigated to improve reproductive performance. A study on the refinement of feeding protocols for the sustainable mass production of the marine annelid *Marphysa mossambica* started this year. Optimization of light exposure to promote growth and survival of the annelids in the nursery phase (eggs to nectochaete) as well as the utilization of feed-enriched sediments in annelid grow-out rearing containers were tried.

### Silver therapon

Apart from the traditional aquaculture species, several indigenous species with aquaculture potential are also being studied. A study on the growth, reproductive performance and nutritional composition of wild and hatchery-reared silver therapon (*Leiopotherapon plumbeus*) was conducted. Mean monthly gonado-somatic indices (GSIs) in both sexes of wild fish (WS) reached its peak in April while highest mean monthly GSIs in both sexes of cultured fish (HB) was noted in September and was high in February until March.

Proximate analysis of specimens collected from July 2015 to January 2016 showed that muscle protein content was relatively constant in wild and cultured fish. Muscle lipid content was more stable, but much higher in both sexes of cultured therapon than their wild counterparts. The remaining muscle, liver and gonad samples in both sexes of wild and hatchery-bred fish collected in March and May 2016 are being analysed



Feeding schemes are being refined for the mass production of marine annelids (*M. mossambica*). Shown here are two-month old marine annelids fed with biofloc



Sandfish (*Holothuria scabra*) maturation diets are being refined to improve their reproductive performance

for proximate (dry matter, crude protein and crude fat), total lipids and fatty acid composition.

In terms of reproductive performance, the combination of human chorionic gonadotropin (hCG) and ovaprim (10 IU g<sup>-1</sup> + 0.5 mL kg<sup>-1</sup> BW) was still the most effective hormone in inducing ovulation in *L. plumbeus*. Using the most effective hormone, monthly spawning trials in both wild-sourced and hatchery-bred stocks showed that while shorter latency period and slightly higher relative fecundity were achieved for wild females, higher fertilization

and hatching rates were obtained for hatchery-bred females. For the effect of broodstock age on reproductive performance of hatchery-bred stocks, it was noted that younger *L. plumbeus* broodstock had higher spawning success, fertilization and hatching rates compared to older groups. In another experiment, monthly GSI of theraon sampled from fed and unfed WS and HB stocks showed that GSIs in both sexes of HB stocks were similar in both treatment groups. In contrast, GSIs in both sexes of WS *L. plumbeus* were slightly higher in fed than those in unfed group.

## Seahorse

Seahorse *Hippocampus* sp., tissue samples were collected from a study site in Molocaboc Is., Sagay City, the SEAFDEC/AQD seahorse hatchery and a seahorse hatchery in Japan. Genetic characterization (based on sequenced mtDNA cyt b and 16s rRNA genes) confirmed only one species, the *H. comes*, in Molocaboc Island. Sequencing of the same genes in all six species of seahorses and a pipefish were done and phylogenetic trees were constructed to show the relationship among the different species. Primers HiSpiF1 and HiBarF1 were confirmed useful for the species identification of *H. spinosissimus* and *H. barbouri*. For *H. comes*, a microsatellite enrichment library was constructed and 35 primer pairs were designed to amplify potential microsatellite markers. 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.

## Sandfish

To improve reproductive performance of sandfish *Holothuria scabra* broodstock, nutritional approaches were applied apart from environmental manipulation. Survival of the broodstock fed shrimp feed and *Sargassum* powder was 100% when reared for the entire 8-week experimental run. Broodstock fed *Navicula* sp. and powdered *Sargassum* sp. showed decreasing body weight (BW) from the start of the feeding trial through the ten-week monitoring period while those fed powdered shrimp feed grew heavier than those fed *Navicula* and *Sargassum* but the record-

ed weights fluctuated throughout the 10-week feeding experiment. When temperature 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 cold shock treatment.

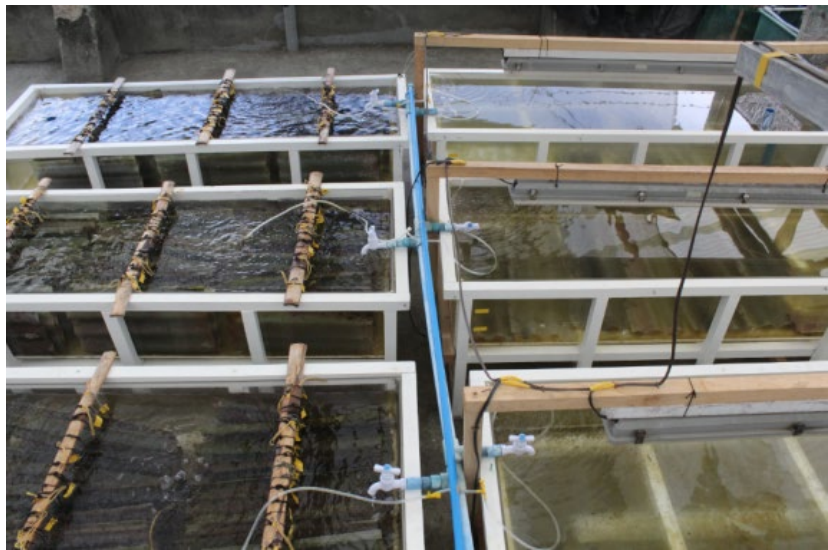
Biochemical data for wild-caught sandfish were analysed and used as basis in formulating the treatment diets. Hatchery-produced potential broodstock were likewise analyzed for proximate composition prior to feeding trials. Whole bodies were used due to the animals'

inadequate sizes (BW < 10 g) as well as the absence of gonads. From the results of the proximate analyses, potential practical diets were developed and are being tested to improve the breeding performance of sandfish broodstock.

## Refinement of hatchery and nursery management to improve seedstock production

### Abalone

In abalone, several refinements were tried to improve larval production and a modified harvesting system was designed that could minimize handling stress and improve veliger survival rates. Other interventions were also made to increase abalone juvenile production through chemical cues (positive ions, algal extracts) to improve settlement rate. Settlement inducers such as gamma aminobutyric acid (GABA) and ammonium chloride were tested. Exposure of abalone larvae to  $10^{-5}$  M GABA induced a higher settlement rate of 48% compared to 0.1 mM of ammonium chloride (23.2%) regardless of settlement substrate. Larvae that were allowed to settle in plates with crustose coralline algae (CCA) and diatoms have higher inductive effect (GABA: 53%; ammonium chloride: 28%). In another experiment, a higher settlement rate of 16.76% was attained after 10d in the treatment with  $\text{NH}_4\text{Cl}$  + diatoms + CCA plates. On the use of illuminated and non-illuminated transparent tanks for settlement and rearing of early juveniles, no significant difference in the settlement and survival rates were noted which means that light is not needed. Finally, an efficient



An experiment on the different orientation of settlement plates for abalone (*Haliotis asinina*) reveal that horizontal spat collector plates lead to better settlement

sorting and harvesting protocol was developed for the abalone and this involved the use of anaesthetic agents as muscle relaxant for juveniles. The use of 1.0ml/L 2-phenoxyethanol for the large-scale trial for harvesting abalone juveniles is recommended.

### Oyster

For oyster, improved larval survival was noted when water change was done once every 4 days. Survival was recorded at 69.9% for larvae kept in rearing water where the first water change is done after 4

days and every 4 days thereafter compared to when water is first changed after 2 days.

In another experiment, larval survival to eyed stage larvae was slightly higher in seawater that has been pre-filtered using a filter cartridge compared to those kept in UV-irradiated seawater. Additionally, three trials showed that mean settlement rates in a hatchery down-welling set-up gave survival rates ranging from 9.1% to 23.4%.

In nursery pond rearing of hatchery-produced spats, faster growth was noted when the spats were transferred to the pond after 88 days of culture in the hatchery. A protocol was also established for transporting competent larvae (eyed-larvae). After 4 hours during transport, survival was higher (76.78%) in larvae transported with water than without (60.83%). Finally, when spats from remote settlement were nursed using fine mesh cylindrical containers in a brackishwater pond, it was observed that specific growth rate was high when using smaller-sized spats than bigger spats.

### Blue swimming crab

For the blue swimming crab *Portunus pelagicus*, larval quality was done through the formalin stress test. After 30 min of formalin exposure, the cumulative mortality became higher as the formalin concentration increased in both poor and good quality larvae. However, cumulative mortality in poor quality larvae was higher than good quality larvae. Larvae used in the stress tests were subsequently reared simultaneously in 1-ton and 3-ton tanks for seed production to validate the results in the small 150-ml enclosures. Survival was recorded until crab instar stage. The batches of larvae that survived only until early zoea were classified as “poor quality batch” and the crabs that reached until crab instar stage as “good quality batch”.

Trials were made as well on the use and non-use of antibiotics in larval rearing. Results showed that blue swimming crab larvae survived without antibacterial agents but the survival rate was lower than those with antibacterial agents (oxytetracycline and nitrofurantoin).

Different feed types were also tested to improve nursery production. Crab instars were fed formulated test diets in combination with mussel meat. All formulated diets, some of which had Peruvian fishmeal, were fed in combination with mussel at a ratio of 70% formulated diet + 30% mussel meat. After 45 days, survival ranged from 22 to 38%, and values were not significantly different. Those fed natural food alone had highest ABW (0.634g) but had the lowest survival of 22%. In Phase 2, the same diets were tested. Survival ranged from 74.72 - 86.67%, and no significant difference was detected.

In another experiment to determine the most economically viable nursery enclosure system and method, crab instar 1 were stocked in aerated tanks, in net cages in ponds, and in hapas inside a big pen at the Igang Marine Station. After 3 weeks, those stocked in tanks gave mean survival rates of 14, 23, and 37% at stocking densities of 1200, 600, and 300

ind/ton, respectively. Phase 2 nursery in tanks gave 35 and 54% survival at stocking densities of 200 and 300/ ton, respectively.

In net cages inside ponds, stocking densities used for Phase 1 nursery were 100, 50, and 30 ind/m<sup>2</sup> which gave similar survival rates of 43, 44, and 54%, respectively. A higher stocking density of 150 ind/m<sup>2</sup> was also tested and this resulted to a mean survival rate that was comparable to both 100 and 50 ind/m<sup>2</sup>. Further rearing for three more weeks (Phase 2) gave survival rates of 62, 64, and 80% at stocking densities of 10, 20, and 30 ind/m<sup>2</sup>.

For nursery rearing in hapas inside pens, stocking densities of 30, 50, and 100/m<sup>2</sup> gave survival rates of 32.41%, 25.89% and 14.22%, respectively. Phase 2 for the hapas inside pens still have to be conducted. Once the runs are completed, a financial analysis will be made to determine which system is economically feasible



Oyster (*Crassostrea iredalei*) nursed in a suspended bucket nursery resulted in a higher specific growth rate when using smaller-sized spats than bigger spats

## Seaweed

Nursery rearing techniques have been refined for *Kappaphycus* culture. Tissue cultured cultivars are produced in the laboratory and reared in the land-based nursery tanks and in sea cages. Thus far, production output from the land-based nursery is about 8,000 *Kappaphycus* plantlets per month. In land to sea based nurseries, the survival rate is 35% with a production output of approximately 2,500 individuals per month from the sea-based nursery.

Meanwhile tissue-cultured explants were outplanted for grow-out. Cultivars from the nursery were planted in Brgy. Tiabas, San Dionisio for the initial 50 day cycle. *Kappaphycus alvarezii* var. tambalang yielded highest growth rate at 2.28%/day. *Eucheuma denticulatum* var. spinosum and *Eucheuma denticulatum* var. milyon2x yielded lower growth rates at 1.3%/day and -0.63%/day respectively. In Nueva Valencia, Guimaras, *Kappaphycus alvarezii* var. tambalang and *Eucheuma denticulatum* var. spinosum were planted in 10-m culture lines (seven lines for *K. alvarezii* and 9 for *E. denticulatum*) with 2,000g initial weight of seaweeds per line. Negative growth rates of seaweeds were obtained in April to June (1<sup>st</sup> cycle).

In another area, micropropagated *Kappaphycus* and *Eucheuma* were planted in five barangays in Concepcion, Ajuy, Iloilo. The growth rate of *Eucheuma* was between 3.88 and 5.52%/day and *Kappaphycus*, 6.34 to 8.94%/day. Apart from Ajuy, micropropagated *Kappaphycus* and *Eucheuma* were planted in 5 barangays in San Dionisio, Iloilo. The growth rate of *Kappaphycus* was 5.53%/



Tissue -cultured seaweed explants have been outplanted for grow-out in different towns in Iloilo and Guimaras provinces. Growth rate of laboratory cultivars will be compared with farmed stocks



Milkfish juveniles right after 8-hour transport experiment

day. Finally, micro-propagated *Kappaphycus* and *Eucheuma* were planted in 5 barangays in Panobolon, Guimaras. Growth of *Eucheuma* was 1.45%/day while *Kappaphycus* grew at 2.05%/day.

Growth of the cultivars from the laboratory and that from farmed stocks shall be compared once farmed seaweeds become available.

## Milkfish

In milkfish *Chanos chanos*, a study that aims to develop a protocol in transporting milkfish juveniles (with an average total length of 5-6 inches) from the nursery to sea cage facilities was conducted. Initial results showed no significant difference in the survival of milkfish juveniles after 7 days when transported for 6



hours under different salinity and temperature conditions. Trials on the suitable conditioning period of confinement in cages in ponds before the juveniles are transported to milkfish sea cage farming sites have been conducted as well.

## Sandfish

Meanwhile, 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.

*Chaetoceros*-fed sandfish larvae had better survival, faster development and less deformities. Sandfish larvae fed *Chaetoceros calcitrans* had decreasing survival rates through the various phases (from early to late auricularia). A sharp decrease was observed during the late auricularia to settlement stage (8-12 days post-fertilization or DPF). Although not significantly different, highest survival at 12 DPF was observed in larvae fed 30,000 cells/ml (69%) and lowest in larvae fed 10,000 cells/ml (65%).

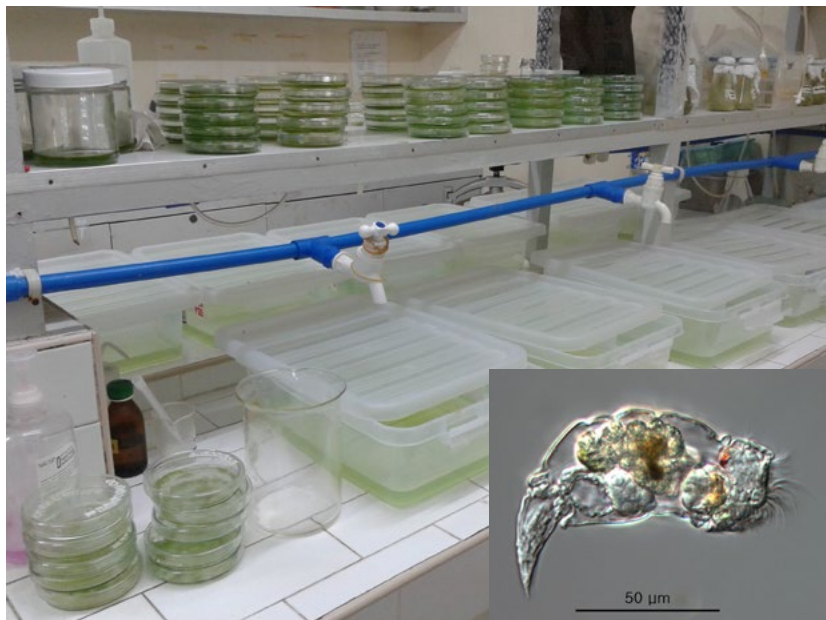
Another run of the same experiment will be done using larvae from broodstock collected from other sites. In another experiment, four settlement cues were compared: *Navicula* sp., *Amphora* sp., *Spirulina* paste and *C. calcitrans* paste. Corrugated plastic sheets were used as settlement substrates. Percent settlement was significantly

high in plates with *Spirulina* paste (20.61%) as settlement cue. However, spats on substrates with *Navicula* sp. and *Spirulina* paste were bigger. Bloodworms were observed on the substrates with *Navicula* sp. and *Amphora* sp. as cue. Repeat runs of the same experiment will be conducted using larvae produced by broodstock collected from other sites.

## Larval food

In larval rearing, it is important to identify and propagate zooplankton species/strains that can be used as live feed for initial feeding to small-mouthed fishes. A study on the growth and reproductive performance of

a minute rotifer, *Proales similis* (Hagiwara, Nagasaki University) fed locally available microalgal strains, is being conducted. Culture of *P. similis* was successful in the laboratory using 0‰ and 15‰ *Chlorella sorokiniana* pastes as these improved the rotifer population growth. Cultivation of *C. sorokiniana* using cheaper commercial fertilizers is viable. Using an 8-well dish culture, a maximum of 2,030 ind/ml was obtained using 15‰ centrifuged *C. sorokiniana* concentrate. The centrifuge as a method of concentrating *C. sorokiniana* showed better results at 1,370 ind/ml as compared to the electrolytic method.



Stock and indoor cultures of the minute rotifer *Proales similis* (inset) in the Larval Food Laboratory

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

## Mangrove crab

For the mangrove crab *Scylla serrata*, a mass selection scheme targeting improvements in growth and disease resistance commenced with the collection of founder stocks from Camarines Norte and Surigao. Crablets were produced from the founder stocks and used in the growth and health status (post-WSSV challenge) assessment. Growth in three-size groups of juveniles from Camarines and Surigao populations were evaluated.

The specific growth rate of crab juveniles from Surigao-sourced broodstock was higher in small-size crabs than the normal growing (medium) and big-size crabs after 192 days of culture. The specific growth rate was comparable in medium and big crabs. Specific growth rates of two batches of crab juveniles from Camarines-sourced broodstock were comparable in three-size groups after 185 and 97 days of culture. Two more batches of juveniles are being grown for evaluation. All the batches of crabs will be cultured until the adult stage and will later form the control (average sized crabs) and selected (big sized crabs) for use as parents in the production of the next generation offspring as part of the selection program.

Meanwhile, some batches of crabs (P<sub>0</sub>A and P<sub>0</sub>B) belonging to the same spawns used in the growth experiment were subjected to disease (white spot syndrome



Mangrove crab (*Scylla serrata*) juveniles from the nursery phase for stocking in grow-out ponds

virus) challenge tests. Preliminary results showed batch differences in relation to the response (mortality levels) to the infection. In comparing batches P<sub>0</sub>A and P<sub>0</sub>B, a difference in mortality of about 10% in P<sub>0</sub>A (23.34%) and P<sub>0</sub>B (33.33%) at the same challenge dose (1x10<sup>-4</sup> LD<sub>50</sub>/crab) was noted. The results of these disease challenge tests will be used to identify disease resistant lines for the selective breeding program.

## Abalone

Hybridization is being continuously implemented using the local commercial abalone species, *Haliotis asinina*. *H. asinina* has been crossed with other Philippine abalone species, *Haliotis planata*, *H. glabra* and *H. varia*, to enable the

production of stocks/species with improved traits.

Results showed that pure *H. asinina* and hybrid *H. glabra* HAFGM attained optimum growth after 420 days of culture (*H. asinina*: 38.6 g; hybrid *H. glabra*: 36.0 g) while hybrid *H. planata* HAFPM attained optimum growth at a longer culture period of 450 days of culture, but heavier (44.16 g). The stocks were being grown to become potential broodstock. These are monitored twice a month to check for spawning and reproduction. Samples of the hybrid stocks have been analysed histologically and will also be analysed for molecular marker-based species differentiation.

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Meanwhile a sensory evaluation test was done to determine acceptability (based on consumer-desired traits) of the hybrids that have been produced (as compared to the pure stocks). Respondents have been limited to ordinary consumers. Plans are underway for a third-party validation of the sensory evaluation with respondents hopefully coming from professionals (e.g. Japanese and/or restaurateur-consumers) with discriminating palates.

### Seaweeds

Methods to develop ice-ice disease resistant strains of the seaweed *Kappaphycus* and reduce epiphytes are being studied. Seaweeds with epiphytes were collected and subjected to different pH levels to determine the epiphytes' survival under the aforementioned conditions. Seaweeds with *Neosyphonia* (red), *Ectocarpus* (brown), *Ulva* (identity to be confirmed) (green) epiphytes were exposed to pH levels ranging from

pH 3 to pH 11. Mortality (pigment loss) of *Neosyphonia* (red epiphyte) was observed after 11 min of exposure in pH 3 and 4; 20 min in pH 5; 30 min in pH 9, 10, 11. Mortality of the *Ulva*-like species was observed after 21 min in pH 3, 4, 5 and; 30 min in pH 9, 10, 11. No mortality was observed in pH 6, 7, 8 after 1 hour. This will be repeated when enough epiphyte-infested thalli are noted and a re-run will be done to refine the methodology.

## Adoption of economically viable systems to produce sufficient seedstock

Several fish/shellfish production projects are being implemented at AQD to demonstrate the viability of small-scale and/or large-scale seed production systems. Mass production of Nile/red tilapia fry/fingerlings (both in the Binangonan Freshwater Station and the Tigbauan Main Station), giant freshwater prawn post-larvae, as well as large-scale production of abalone juveniles, are continuously being done.

The quality seed program has addressed several pressing issues that involve the need to provide improved or better quality seedstock that will boost, if not promote sustainable aquaculture production. Refinements in all the important aspects of fish breeding, hatchery and nursery operations are being pursued with the hope that whatever outputs may be achieved, can directly benefit the aquaculture industry in the region.

# Healthy and Wholesome Aquaculture

The sustainability of increased aquaculture production is dependent on the provision of adequate and environment-friendly feed and feeding practices. Proper fish health management is equally important to prevent or mitigate losses from diseases.



SEAFDEC/AQD is monitoring the sanitary quality of major oyster culture sites. Shown here are oysters harvested after eight months of culture in Agojo River in Capiz Province

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Alternative sources of protein for feeds identified

—  
Taurine found to be essential during early stages of pompano growth

—  
Three farms successfully adopted improved soft-shell crab production technology

—  
Indian almond leaf extracts shown to provide antibiotic-like protection to early crab stages

## OBJECTIVES

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

- Find alternative protein sources to replace fish meal in dietary formulations
- Determine specific nutrients that enhance growth performance
- Promote practices or strategies to improve production
- Investigate the efficacy of probiotics
- Rationalize the need and application of diagnostics that will ensure biosecurity within culture systems
- Promote the wider use of conventional and new diagnostic methods, especially for newly reported emerging diseases;
- Find effective and safe alternative drugs/chemicals (including natural products) to manage aquaculture diseases

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## Finding alternative protein sources to replace fish meal

Fish meal, a major source of protein in aquaculture feed is considered a finite resource and although its inclusion in commercial aquaculture feed had decreased, the usage continues to increase due to the enormous volume of feed produced for the fast growing industry. Protein from alternative sources are included in formulations to reduce fish meal protein in diets of important aquaculture species such as milkfish and pompano.



Abalone (90 days DOC) fed with diet containing enriched *Ulva pertusa* at 30% replacement level

Distillers dried grain solubles (DDGS) a by-product of the distillery industry has significantly improved milkfish final body weight and FCR at a dietary inclusion level of 30% without morphological changes in the liver and intestine. Another source of protein is a hydrolysate that is processed from milkfish by-products which can be

used at an inclusion level of 10% in larval diet for pompano. Another alternative source of protein, the seaweed *Ulva pertusa* can be enriched with ammonium chloride to increase its nitrogen content. The dried form was found to effective-

ly replace protein coming from fish meal and soybean meal in abalone (*Haliotis asinina*) diet at a dietary level of 30%. Abalone fed this level had the highest growth rate and its body composition was not affected.

## Determine specific nutrients that enhance growth

In developing feeds, supplementation with essential nutrients is necessary especially for the early stages of growth. For grow-out, essential amino acids are important. These should be provided in the ration as they may not be in adequate quantities for the growing stock compared to when these are grown in the wild.



Pompano (*Trachinotus blochii*) fed formulated diets weighing about 350g showing the golden color of the dorsal part

For seabass, the dietary levels of three essential amino acids (leucine, isoleucine and histidine) for optimum growth are being determined. For pompano, taurine was found to be essential during its early stages ( $\leq 20g$ ) of development. Growth was significantly enhanced when the total amount of taurine in the diet was 1.877% (0.377% basal

level + 1.5% supplement) which coincided with the level of taurine in pompano flesh (also 1.877%). The bigger size pompano (100g to

352g), however, was observed to not require taurine supplementation if fed a diet containing 0.377% taurine.

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## Promote practices or strategies to improve production

The DOST-PCAARRD funded a study on the establishment of a commercial soft-shell crab farm to demonstrate the practices that improved production. This was successfully adopted by three farms in the Philippines with one farm capable of producing 200 pieces of soft-shell crab a day. For another crustacean species, *Penaeus indicus*, the quality of seeds produced by captive, hatchery-bred broodstock were at par and even better in terms of survival compared to seeds from wild broodstock. Also, it was found to be economical to stock the shrimps at 20/sqm with a culture period of 90 days. In the production of two species of grouper in ponds using SEAFDEC/AQD phased-diet, final weights of fish ranged from 400 to 460g and survival rate was about 94% after 6 or 8 months of culture.



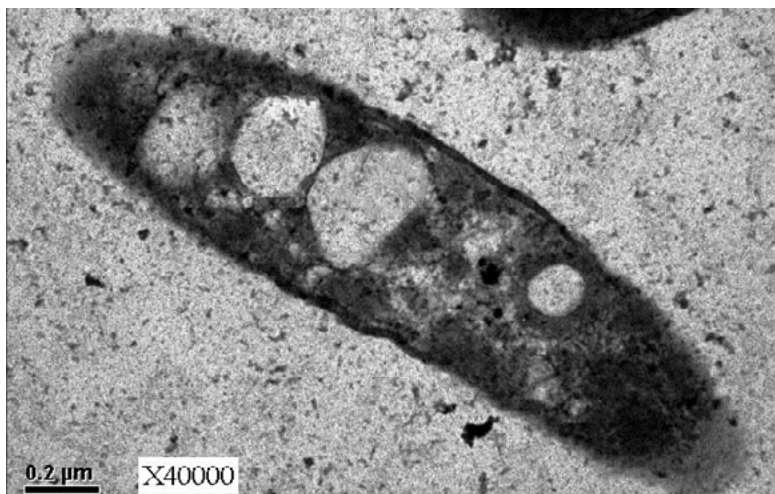
The size increment of crab after molting showing the exuvia and the soft-shell crab

## Testing the efficacy of indigenous probiotics

The protective effects of *Bacillus* sp. JL47 containing different levels of amorphous Poly- $\beta$ -hydroxybutyrate (PHB) was examined using gnotobiotic *Artemia*. The *Bacillus* isolate was grown to accumulate different levels of amorphous PHB (29% and 55% PHB cell dry weight), fed to gnotobiotic *Artemia* nauplii, and subsequently challenged with *Vibrio campbellii* LMG 21363 at 6 hours post-feeding. *Artemia* nauplii fed *Bacillus* sp. JL47 with 55% PHB resulted in a significantly higher survival rate than those fed with *Bacillus* sp. JL47 with 29% PHB. Complete protection against pathogenic *Vibrio campbellii* was observed in *Artemia* fed *Bacillus* sp. JL47 with 55% PHB indicating that the protective effects of *Bacillus* sp. JL47 is superior when it contains higher amount of amorphous PHB.

Moreover, a study on the effects of PHB-accumulating *Bacillus* sp. on the water quality and thermal stress response of *Penaeus monodon* postlarvae during culture is currently underway. Additionally,

the efficacy of commercial probiotics and a disinfectant in controlling acute hepatopancreatic necrosis disease (AHPND) and luminescent vibriosis in *P. vannamei* culture is being investigated.



Transmission electron micrograph of *Bacillus* sp. JL47 containing the intracellular amorphous PHB

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## Application of diagnostic tools for biosecurity

To examine the sanitary quality of major oyster culture sites in the Western Visayas Region, 2 major oyster production areas located in Cabugao Bay, Municipality of Ivisan and in Agojo River, Municipality of Panay, both in the Province of Capiz were investigated for fecal coliform count (FCC) and *Escherichia coli* count (ECC); *Vibrio parahaemolyticus* count (VpC); and presence of *V. cholerae* (Vc) and *Salmonella* in the rearing water and oysters' meat, respectively. Sampling stations in Agojo River have lower FCC from January until March (15 to 52 MPN/100 ml). Regardless of the fact that two stations are located downstream and midstream wherein several households have been confined along the riverbanks, the lower FCC may be attributed to the sporadic rainfall in the area during the sampling period. ECC in oysters obtained from Cabugao Bay sampling stations were generally higher (1,725 to 2,220 MPN/100 g).

Oysters are filter feeders and have the ability to concentrate bacteria from surrounding seawater in their digestive system. *E. coli* is normally found in the feces of humans and warm-blooded mammals, hence, the ability of *E. coli* to survive in the water of oyster production areas serves as indicator of fecal contamination. VpC in oysters' meat collected from all sites were below the detection limit. In addition, while Vc was not detected in all oyster samples examined, *Salmonella* was erratically detected.

Oyster samples were also examined for the presence of heavy metals during wet/rainy and dry seasons. The level of copper (Cu) in oysters'



Rafts deployed in Agojo River, Panay, Capiz

meat collected from all sampling sites ranged from 11.51 to 14.70 ppm while zinc (Zn) ranged from 35.1 to 55.3 ppm during the wet season. The level of cadmium (Cd), chromium (Cr), lead (Pb), and mercury (Hg) were nil or below the detection limit. Moreover, the quantity of Cu (19.84 to 37.93 ppm) and Zn (44.81 to 82.51 ppm) in oyster samples collected during the dry season were relatively higher compared with results of the wet season. Cd (0.63 to 0.97 ppm) was surprisingly detected in oysters collected from all sites. The levels of Cr, Pb, and Hg in oysters' meat were likewise nil or below the detection limit.

Because microbiological examination of oysters examined in the current and previous year revealed that oysters in Cabugao Bay need to be relayed or depurated, in the succeeding experiment, the potential of the 3 relaying stations located in the deeper portion of Cabugao Bay (ca. 1.5 to 2 km away from the existing oyster production areas)

was examined. Over 1 year, FCC of the water was generally <43 MPN/100 ml (categorized as an *Approved Area* based on *US National Shellfish Sanitation Program Shellfish Harvesting Area Classification Criteria*). The effect of relaying on ECC in oysters' meat during the wet and dry seasons were also examined. Initial ECC in oysters deployed in relaying sites (RS) 1 and 2 during the wet season were 800 MPN/100 and 990 MPN/100 g, respectively. In the control site, the mean ECC in oyster samples was 12,700 MPN/100 g. After 7 days, ECC in oysters obtained from RS1 and 2 decreased to <20 and 70 MPN/100 g, respectively. In addition, the ECC in oysters obtained from these 2 stations significantly dropped to <20 MPN/100 g at 3 weeks post-relaying while the control site was still high ( $\geq 1,300$  MPN/100 g). This demonstrates the potential of the identified sites for relaying oysters harvested from the nearby areas.

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## Promoting the wider use of conventional and new diagnostic methods

Shrimp samples were collected from farms in 14 out of 17 regions of the Philippines from 2014 to 2016. The samples were subjected to bacterial and viral pathogen detection using a combination of bacterial isolation, biochemical characterization, PCR, and whole genome sequencing.

In 2014, out of 5 regions sampled in Visayas and Mindanao, 2 regions (VI, and IX) were positive for WSSV. From January 2015 to March 2016, out of 13 regions sampled, 4 regions (V, VI, VIII and X) were WSSV-positive with highest occurrence in Region V at 53.13%. For acute hepatopancreatic necrosis disease (AHPND), samples were gathered from 9 regions of which only Regions III, IVB, VI, VII, VIII and XI were AHPND-positive.

All the isolates and tissue samples were stored at -80°C freezers at the biobank room using an archiving system that allows easy sample management. Eleven bacterial isolates were identified to contain the specific PirA- and PirB-like toxin gene responsible for AHPND pathogenesis.

Experimental infection of healthy shrimp with these isolates, using a previously published laboratory infection model, caused 100% mortality after 24 hours which was accompanied by characteristic AHPND histopathology and confirmed to be AHPND-positive by PCR analysis. Further tests revealed that the mortality rate was dose- and size (age)-dependent. These results showed that the isolated *V. parahaemolyticus* derived from outbreaks in Philippine shrimp farms are highly pathogenic to shrimp.

Records of all the archived isolates are stored in an online database called the Online Philippine Shrimp Pathogen Information Resource (OPSPIR). It contains epidemiological information of gathered samples including host, collection site, water quality parameters, pathogen, and isolates. It was built using PHP scripting language and MySQL format making it expansion ready and available to any web browser online. OPSPIR geotags the presence of pathogens with the use of Google Maps. It currently runs at <http://www.opspir.seafdec.org.ph>.

Aside from the present bio-surveillance records, data from other sources were included to reflect the historical presence of diseases in the areas covered.

To sustain continued bio-surveillance, cooperation among government agencies and local government units, the private sector, and other stakeholders to conduct remote data entry (RDE) is needed for early detection and mitigation of disease outbreaks.

With regard to 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, current data demonstrated that the detection limit of LFSB kit is at par with the nested-step optimized WSSV PCR method. The LFSB kit provides a cost-effective DNA-based biosensor which can be readily modified and adopted to target emerging strains of WSSV as genome data for WSSV strains from the Philippine Genome Center (PGC) become available.



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## Evaluating the effectiveness of natural products to manage aquaculture diseases

Terrestrial plants and indigenous bacteria were investigated for their antimicrobial and probiotic properties as one of the practical strategies to manage diseases of mud crabs in hatchery and grow-out ponds. Plant samples were gathered from different locations in Panay. Crab samples were also collected from Capiz and Northern Iloilo to isolate potential probiotic bacteria. Preparation of crude extracts and testing for *in vitro* antimicrobial activity was subsequently conducted. During this time, collection of additional bacterial isolates from Lanao del Norte and Pampanga was also undertaken.

Extracts that showed good antimicrobial activity by agar disc diffusion technique were further tested for their toxicity to various stages of crabs including zoea, megalopa, and crab instar. In vivo efficacy of the extracts was also determined in crab instar by oral administration and injection followed by experimental infection with *V. harveyi*. *Bacillus* spp. were isolated using selective media and further tested for their antimicrobial and quorum sensing inhibitory activity. Extracts and bacterial isolates showing good antimicrobial, quorum sensing, and in vivo efficacy as evidenced by conferment of protection

against *V. harveyi* challenge were examined using simulated hatchery and grow-out trials.

Results showed that *Terminalia catappa* crude ethanolic extracts was comparable to the antibiotic treated group in terms of survival at the zoea 5 and crab instar 1 stages. However, diseases of non-infectious etiologies can also have a serious impact on the final survival, and hence, should receive utmost attention in developing best management practices for *Scylla serrata* hatchery.

# Maintaining Environmental Integrity Through Responsible Aquaculture

The adverse effects of aquaculture to the environment should be reduced through the integration of culture systems developed through intensive research.



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Three sites established for community-based sea ranching  
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Abalone grew best in tanks compared to ponds and reef flats and with lower stocking density  
—  
Hatchery-bred oyster spats grew larger compared to wild-sourced oysters  
—  
100% survival achieved in transporting seahorses for 10 to 12h  
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## OBJECTIVES

Develop environment-based aquaculture technologies and promote responsible aquaculture practices

- Develop and promote efficient and suitable environment-friendly culture systems
- Conduct biological and ecological studies on species with potentials for resource enhancement

Sandfish (*Holothuria scabra*) pens at Molocaboc Island, Sagay City, Negros Occidental. Sandfish are produced in on-site nurseries to support community-based sea ranching

# Develop and promote efficient and suitable environment-friendly culture systems

The development and promotion of efficient and environment-friendly culture systems for the following commodities are being undertaken: sandfish *Holothuria scabra*, abalone *Haliotis asinina*, slipper oyster *Crassostrea irredalei*, giant freshwater prawn *Macrobrachium rosenbergii*, penaeid shrimps, and seaweed *Caulerpa lentillifera*.

## Sandfish

For sandfish, three sites were established for community-based sea ranching, with each site having its own sandfish nursery set-ups which produced thousands of juveniles. These sites are (1) Brgy. Polopina, Concepcion, Iloilo, (2) Brgy.

Pandaraonan, Nueva Valencia, Guimaras, and (3) Molocaboc Island, Sagay, Negros Occ. Table 1 shows the production of juveniles in these three sites.

## Abalone

Studies on abalone revealed that after 119 days, those cultured in tanks grew best compared to those reared in ponds and reef flats. Those with lower stocking density of 200 ind/m<sup>2</sup> had the highest shell length and body weight (3.41 cm SL and 8.42g BW), compared to 400 ind/m<sup>2</sup> (3.19cm SL and 7.27g BW). No significant difference in survival was observed in the tanks and reef flats between the two den-

sities, but survival in ponds was low.

## Oysters

Oysters reared in different sites showed different production traits as shown in Table 2, with the highest growth rate observed in New Washington, Aklan. Hatchery-bred and wild-sourced oyster spats were also compared by growing out in pouches. Results showed significantly higher body weight (92.5g vs. 88.1g) and shell length (100.6mm vs. 94.0mm) in hatchery-bred compared to wild-sourced oysters, but the latter showed significantly better survival (90.8% vs. 85.8%).

Sandfish nursery production runs at 3 sites (2015 and 2016)

	Igang		Concepcion		Sagay	
	2015 (Jan-Dec)	2016 (Jan-Aug)	2015 (Jan-Dec)	2016 (Jan-Aug)	2015 (Jan-Dec)	2016 (Jan-Aug)
Nursery runs	6	2	6	4	2	4
Total S1 stocked	26,443	8,087	25,101	52,500	20,854	39,745
Mean Survival (60 DOC)	8.9%	27.7%	32.3%	11.4%	26.8%	13.9%
Juveniles (>3 g) released in pens	1,397	1,388	5,580	1,662	3,205	5,053
Juveniles (>20g) released at sea ranch	0	0	512	0	216	616

Growth rates of oysters reared in Batan Bay, New Washington, Aklan; Dacutan River, Dumangas, Iloilo; and Tinagong Dagat Bay, Ajuy, Iloilo.(2015 and 2016)

Site	Growth rate (length, mm per month)		Growth rate (weight, g per month)	
	Range	Mean	Range	Mean
New Washington	0.77-9.10	5.45±0.98 <sup>a</sup>	6.80-13.33	9.87±0.78 <sup>a</sup>
Dumangas	1.90-5.20	3.42±0.48 <sup>ab</sup>	3.40-9.00	5.66±0.67 <sup>b</sup>
Ajuy	0.00-2.52	0.72±0.48 <sup>b</sup>	0.80-2.90	1.67±0.35 <sup>c</sup>

## Giant Freshwater Prawn

The biofloc system of rearing the giant freshwater prawn with sugar as the source of carbon is on-going. Results of runs in indoor circular fiberglass tanks at different stocking densities (30, 40 and 60 prawns per m<sup>2</sup>) showed no significant differences in survival, but significantly higher final weight in the middle stocking density. However, FCR is quite high in all treatments probably due to the low survival observed in this run. Results are summarized in Table 3.

The effect of cheliped ablation on the production performance of cage-cultured giant freshwater prawn was also conducted with results showing no significant advantage provided by ablation since there were no significant differences in final weight, growth rate and survival of prawns in the control and the ablated group (Figure 1).

## Aquasilviculture

Aquasilviculture as a method of responsible aquaculture has just started to assess factors affecting nutrient removal dynamics between mangrove and shrimp farms in order to establish the appropriate shrimp pond to mangrove area ratio. Ponds for the trials have been rehabilitated and prepared. Eventually, the aquasilviculture of shrimp as an ecosystem-based



Male giant freshwater prawn with unablated claw and with ablated claw that has regenerated

management strategy for sustainable production will be promoted in ASEAN countries.

## Seaweed

A study on optimizing the culture of *Caulerpa lentillifera* in tanks and ponds is on-going to quantify nutrient, salinity, and light requirement of the species. The chlorophyll as well as the carotenoid content at these different culture conditions will also be determined. *C. lentillifera* at 50 and 100 ppm NH<sub>4</sub>Cl had the highest

percentage nitrogen content in its thallus as shown in Figure 2. In another experiment *C. lentillifera* was cultured in tanks with the following treatments: Treatment 1 no fertilizer (control), Treatment 2 (50 ppm NH<sub>4</sub>Cl), Treatment 3 (50 ppm NH<sub>4</sub>Cl + 10 ppm ASL), Treatment 4 (10 ppm NaNO<sub>3</sub>) and Treatment 5 (50 ppm triple 14). Results showed that after 121 days of culture, the Control had the highest SGR (0.03% per day) and treatment using triple 14 had the lowest SGR (-0.48% per day) (Figure 3).

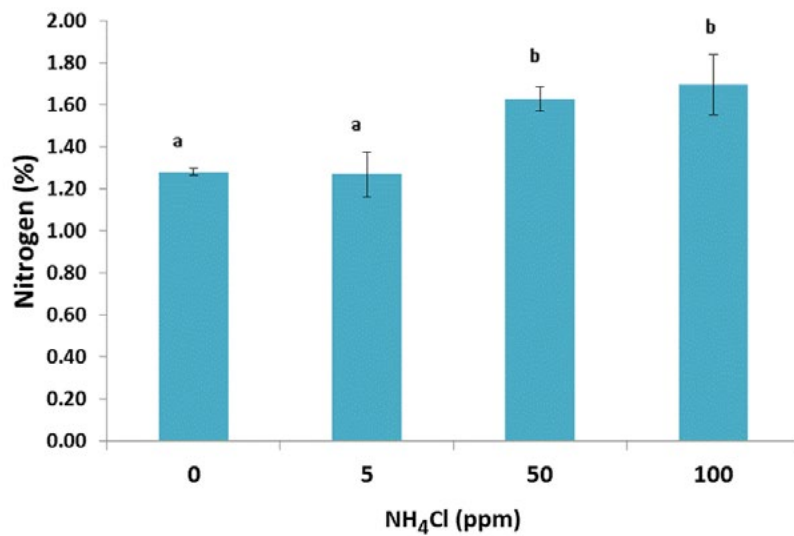
Production parameters of giant freshwater prawn reared in indoor fiberglass BFT biofloc system at different stocking densities after 5 months of culture

Parameter	30 pcs m <sup>2</sup>	40 pcs m <sup>2</sup>	60 pcs m <sup>2</sup>	P value
Final weight, g	17.0±1.5 <sup>ab</sup>	19.1±1.8 <sup>a</sup>	15.1±0.9 <sup>b</sup>	0.0108
Survival, %	44.8±12.9	34.0±9.0	35.5±6.4	0.2963
SGR, %	1.15±0.07 <sup>a</sup>	1.18±0.04 <sup>a</sup>	1.05±0.05 <sup>b</sup>	0.0295
FCR	4.3±0.6 <sup>a</sup>	6.1±1.0 <sup>b</sup>	6.6±0.4 <sup>b</sup>	0.0034

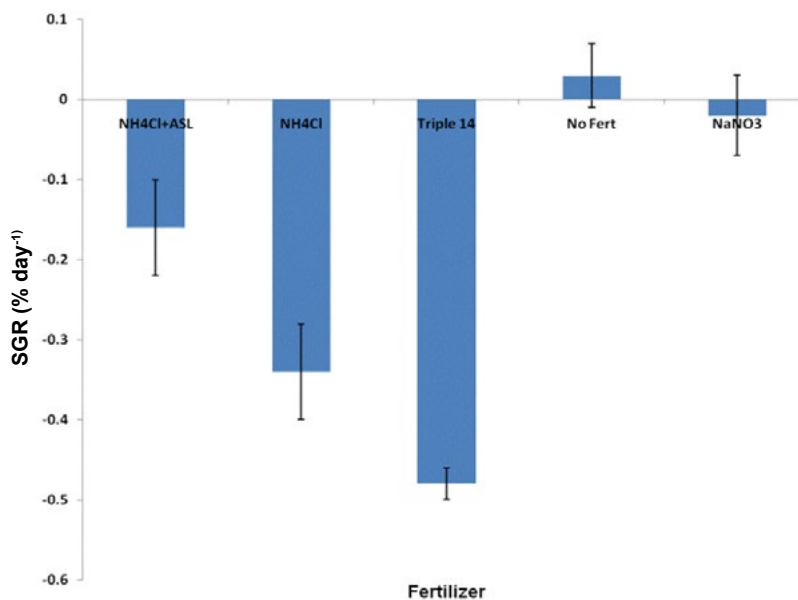
## Conduct biological and ecological studies on species which are candidates for resource enhancement

A study on seahorse funded by the Government of Japan Trust Fund is underway. In order to improve the stock population in the wild, hatchery-bred seahorse is released. Thus far, transport strategies lasting from 10 to 12 hours with 100% survival rates of adults at stocking densities of 1, 2 and 3 individuals per liter has been achieved.

As preparation for the community in Molocaboc Island, Sagay, Negros Occidental for the stock enhancement of seahorse in the area, the release is integrated with information, education and communication (IEC) activities for school children, teachers and fisherfolk organization members.



Thallus Nitrogen of *C. lentillifera* after 4 hours of incubation at different NH<sub>4</sub>Cl concentration



Growth of *C. lentillifera* in tanks using different fertilizers (121 days of culture) under different nutrient conditions

# Adapting to Climate Change

As patterns of water temperature and salinity in the culture environment shifts, there is a need to recognize its effect on the physiological condition of several aquaculture species. Much study is needed to simulate possible environmental changes and develop technologies to mitigate the problems that may occur.



Rabbitfish, *Siganus guttatus*, was previously demonstrated to still spawn successfully even at elevated temperatures of 31-33°C. However, eggs were aborted at 33°C and hatching rate was lower at 31°C

Reproductive performance of milkfish is being recorded in order to correlate to environmental parameters

Training courses continue to integrate the effects of climate change on aquaculture

## OBJECTIVES

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

- Gather scientific information on the susceptibility of various economically important aquaculture species to the combined effects of high seawater temperature and acidity
- 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
- Promote awareness on the possible effects of climate change to aquaculture
- 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
- 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
- Explore potential adaptive measures to mitigate the impacts of climate change to different aquatic farming systems
- Collaborate with other institutions in the country and in the region in gathering scientific information that will serve as basis for the design of alternative aquaculture systems that are adaptive to climate change

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# Meeting Social and Economic Challenges in Aquaculture

Securing food and profit among stakeholders can be realised through collaborations in implementing social and economic strategies in aquaculture and resource management.



Harvesting seaweed in Nueva Valencia, Guimaras as part of an Integrated Multi-Trophic Aquaculture system

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SEAFDEC/AQD - JIRCAS collaboration renewed

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Three consecutive croppings in IMTA milkfish pen culture brought gains to fishers

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Abalone have spilled over from initial release site and are now caught and sold by fisherfolk

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## OBJECTIVES

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

- Prioritize collaborative R&D in aquaculture to have a clear assessment and understanding of the role of aquaculture in poverty alleviation and provide basis for policy formulation
- Allocate R&D resources to address emerging issues on the impacts of climate change and global trade on aquaculture with emphasis on small-holder fish farmers
- Enhance multi-agency collaboration, sharing of information and resources to alleviate the socioeconomic conditions of the poor sector

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## Prioritize collaborative R&D in aquaculture to have a clear assessment and understanding of the role of aquaculture in poverty alleviation



Upscaled IMTA milkfish pens operated by 6 fisherfolk cooperators trained through on-site demonstration and verification in Barangay Pandaraonan in Nueva Valencia, Guimaras province

The collaborative JIRCAS-funded project on Integrated Multi-Trophic Aquaculture (IMTA) was renewed for another 5 years. The project aims to develop smallholder IMTA strategies suitable as supplemental livelihoods for subsistence fisherfolks.

Fishers from Pandaraonan in Nueva Valencia were trained and performed the daily activities in IMTA milkfish production system that aims to address the environmental impacts of excess nutrients from feeding and fish feces, while improving economic gains from harvest of non-fed sandfish and nutrient-absorbing seaweeds.

The study has completed 3 consecutive croppings which demonstrated improved economic gains from milkfish harvest. However, sandfish produced utilizing the IMTA protocol needs further evaluation to sustain survival until harvest. In addition, seaweeds harvested for two croppings using similar set-up had a significant increase in yield.

Another study aims to determine the economic benefits and losses of seaweed farmers due to some climate change indicators. Reconnaissance survey was conducted both in Panobolon and Guiwanon Islands in Nueva Valencia to serve as baseline reference in future evaluation of benefits and losses due to changes in climate parameters. Seaweed growers reported

problems related to the decline of their harvest. These include the lack of new sources of seaweed propagules, low buying price of dried seaweeds, lack of start-up financial assistance, and climatic factors such as drastic change of temperature, changes in quantity and frequency of rainfall, and the presence of extreme events such as typhoons.



A Memorandum of Agreement was signed for a 5-year collaboration between SEAFDEC/AQD and JIRCAS for the years 2016-2021



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## Enhancing multi-agency collaboration, sharing of information and resources to alleviate the socioeconomic conditions of the poor sector

The Program has been implementing studies on Community-Based Resource Enhancement (CBRE) since 2006 to address declining fish catch and income in remote island communities in the Visayas. These studies include enhancement of threatened resources such as abalone *Haliotis asinina* and sandfish *Holothuria scabra* in Molocaboc Island in Sagay Marine Reserve in Negros Occidental; and shrimp, *Penaeus monodon* in Pinamuk-an in New Washington Estuaries in Aklan province since 2012.

The Molocaboc Sea Ranchers' Association (MOSRA) composed of fisherfolks who have been actively involved in CBRE in Sagay for the 10-year duration of the project already harvest and sell abalone recruits from tagged hatchery-bred abalones first released in 2011. Spill-overs both from abalone and sandfish have been reported by gleaners in intertidal areas outside



Local fisherfolk show the sandfish (left) and abalone (right) collected from around the coralline release site

the release site. Monitoring of released tiger shrimps in Aklan province showed that various sizes add to the catch. However, prohibitions on the use of illegal gears such as fine mesh nets should be imple-

mented by the LGU. These gears cause economic losses because released under-sized shrimps were caught and sold at lower prices together with other smaller shrimp species.



Key stakeholder-collaborators (representing fisherfolk, local government, the academe, and a research institution) involved in the shrimp stock enhancement project in Aklan province conducted its evaluation meeting

These CBRE studies demonstrate the importance of tri-party partnerships between organized fisherfolks, their local government and fishery research institutions in successful implementation of resource enhancement as a fisheries management initiative.

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# Promotion of Sustainable Aquaculture and Resource Enhancement

The Government of Japan (JTF6) has been providing funds for the implementation of this program which is implemented in collaboration with partners in the ASEAN region. Its projects are (1) Reinforcement and optimization of fish health management and its dissemination in Southeast Asia, and (2) Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources.

## OBJECTIVES

- Develop and accelerate rapid and effective fish and shrimp health management
- Enhance efficacy of vaccine treatment in tropical cultured species
- Establish protective measures against persistent and emerging parasitic diseases in tropical fish
- Identify risk factors and develop protective measures against EMS
- Extend and demonstrate fish health technologies to member countries
- Establish environment-friendly aquaculture technologies
- Promote community-based production and resource enhancement of high-value aquatic resource
- Disseminate and demonstrate resource enhancement practices

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# Fish Health Project

## Develop and accelerate rapid and effective fish and shrimp health management

Threshold infection levels for WSSV, AHPND and VNN at different age/weight ranges was determined. Several tissue passage to produce infected shrimp tissues and preliminary infection experiments were conducted to determine the threshold level. Healthy shrimp were fed with WSSV positive shrimp tissue at different feeding rates and the 7% ABW feed rate is considered as the LD<sub>50</sub> since within 3 days, 50% mortality was already observed. This LD<sub>50</sub> can be used as basis for the succeeding infection experiment. Infected tissues and dead shrimps were confirmed to be 1-step PCR positive for the virus. Preliminary run of q-PCR was conducted and the standard curve was determined for verifying and correlating the threshold infection levels.

## Enhance efficacy of vaccine treatment in tropical cultured species

The field efficacy of the inactivated NNV vaccine in pompano reared in floating net cages in Igang Marine Station, Guimaras was investigated. Pompano juveniles (n=1,600) with a mean body weight of 5.7g were intraperitoneally (IP) vaccinated with the inactivated nervous necrosis virus (NNV) vaccine (pre-inactivation titer: 10<sup>9.2</sup> TCID<sub>50</sub>/ml) and randomly divided into 2 groups, i.e. 800 individuals per 2 m × 2 m × 1.5 m net cage. The same number of fish was IP injected with

L-15 to serve as control. To examine the kinetics of NNV-neutralizing antibody titer in the sera of both vaccinated and unvaccinated fish, blood samples were collected at the caudal vein of fish (n=10) at Days 30, 60, 90, 120, 150 and 180 (harvest) post-vaccination. Determination of NNV-neutralizing antibody titer in the sera of fish is ongoing. Concomitant to previous tank studies, the inactivated NNV vaccine is anticipated to be likewise immunogenic in activating the production of potent NNV-neutralizing antibodies against viral nervous necrosis in pompano reared in floating net cages in the open sea.

## 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. In 2015, preliminary experiments were conducted to optimize conditions for the production of dsRNA and efficacy trials. These include LD50 test, and isolation of primary cells from shrimp lymphoid organs. LO primary cells have been successfully isolated but growth in L15 medium with supplements were not satisfactory and suggests further improvements in the medium. WSSV infection was carried

out and cells showed CPE at 10-5 dilution of the WSSV tissue filtrate. In the first half of 2016, dsRNA was produced following protocols recommended by the Cold Harbor Springs Laboratory (CHSL). The bacterially-produced dsRNA was quantified by nanospectrophotometry and used in the challenge experiment at 0.2 and 10 µg/µl. Initial results showed significant differences in survival between PBS and 10 µg/µl dsRNA dose on the 5th day post-challenge. Time to reach 100% mortality also significantly differed although all challenged shrimp eventually died. The challenge experiment will be repeated using more replicates and number of samples, wider range of dsRNA doses, different time intervals from dsRNA injection to pathogen challenge, and heterologous dsRNA to test the specificity of gene silencing.

## Establish protective measures against persistent and emerging parasitic diseases of tropical fish

Hematological analyses of blood samples revealed significant differences between monogenean-infected and non-infected fish (*P*<0.05). The hematocrit, hemoglobin and red blood cell count (RBC) were lower in infected fish than in healthy individuals. In contrast, white blood cell count (WBC) was higher in infected fish compared to non-infected fish.

The efficacies of garlic-based treatments against infection with the parasite *Pseudorhabdosynochus*

*lantauensis* in groupers were also tested. The median lethal concentration (LC<sub>50</sub>) of crude garlic extract to grouper at 24, 48, 72 and 96 h of exposure were 6.24, 5.94, 5.15 and 3.66 ml/L, respectively. Experiments on the effect of garlic extract on *in vitro* parasite survival and the efficacy of bath treatment of infected fish using garlic extract are ongoing.

## Epidemiology of EMS/AHPND

Preliminary studies were done to determine the efficacy of water stocked with siganid (SGW) for 4 weeks against AHPND using 2 age groups of *P. monodon*: 150 and 120 days of culture (DOC). In the 130

DOC group, observed survival in VP<sub>AHPND</sub> experimentally infected and the uninfected shrimp maintained in SGW and UV sterilized seawater (UVSW) were not significantly different. In the 120 DOC group, survival in infected (97.12%) and uninfected shrimp (97.08%) maintained in SGW were significantly higher than the infected group (90.42%) maintained in UVSW. Survival in uninfected shrimp maintained in UVSW was 95.95%. Older *P. monodon*, >130 days of culture, may not be susceptible to VP<sub>AHPND</sub>. Bacterial isolation was done on the mucus and feces of siganid. All 6 isolated bacteria and the mucus per se did not have antimicrobial activity against VP<sub>AHPND</sub>. However, antimicrobial activity was observed in the feces.

## Technology extension and demonstration for capacity building of member countries

- 1) A follow-up training course on bacteriology (isolation, characterization, and bioassay) was conducted in October 2016. Fish health officers and faculty & graduate students of Myanmar University were involved in the training.
- 2) As part of the guided research, a proposal submitted by the fish health staff will be reviewed and submitted to the Department of Fisheries, Myanmar for possible funding.
- 3) A specialized training course and guided research will be conducted in Cambodia in 2016.

# Sustainable Aquaculture Project

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

Protein enrichment studies of agricultural wastes by ensiling method or with *Trichoderma harzianum* Rifai by solid state fermentation with and without nutrient addition have been completed and the remaining bioprocessed samples have yet to be analyzed for their protein contents. Pesticide residue (i.e. organochlorines, pyrethroids and organophosphates) analyses have indicated that among the agricultural waste samples examined, mango peel and citrus peel had pesticide levels found to exceed the limit of quantification of 0.01 mg/kg. However, the levels found in these

samples were still lower than the maximum residue limits (MRLs) adopted by the FAO Codex Alimentarius for mango (0.2 mg/kg) and citrus (1 mg/kg) in 2009 and 2013, respectively. The anti-nutritional factors (i.e. tannin, phenols, saponin, lignin, and alkaloid) of all agricultural waste samples which are likely to affect digestibility once incorporated in the tilapia diets are also being analyzed. A preliminary trial to evaluate the protein quality of agricultural wastes in a 28% crude protein diet and their effects on the growth and survival of juvenile tilapia was conducted for 70 days. Fish fed the control diet had the highest final weight, percentage weight gain and specific growth rate. Percentage weight gain of tilapia fed the control diet was comparable to those fed diets containing citrus pulp, okara meal,

and pineapple peel. Furthermore, specific growth rate for citrus pulp, okara meal, and banana peel-based diets were comparable to those of the control diet. There were no significant differences observed among survival rates of fish given control or test diets. The substitution effects of fishmeal with mango peel silage in the diet on reproductive performance and fry production of tilapia broodstock reared in tank- and lake-based cage set-ups are currently being monitored.

## Responsible aquaculture through aquasilviculture

Aquasilviculture pond (separate system; effluent will be drained in environments with and with-

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out mangroves) was stocked with shrimp, *P. monodon* PL 18 at 20 individuals/ m<sup>2</sup>. Shrimp were stocked in hapa nets for 19 days prior to release in earthen ponds. Water used in the pond came from a reservoir with mangrove saplings and incidental native *Tilapia mossambica* (number or biomass is unknown). Shrimp were fed with commercial pellet. No water drain was implemented; water loss due to seepage and evaporation were replenished to maintain a water depth of 90cm. During the first month sampling, survival was 86%; average body weight was 2.0g.

### **Community-based integrated production of abalone, *Haliotis asinina* and sea cucumber *Holothuria scabra***

The 5.5 years of monthly monitoring of 12,640 tagged hatchery-bred (HB) abalone juveniles released in the Community-Based Resource Enhancement (CBRE) site in Molocaboc in Sagay Marine Reserve showed an increasing proportion (91-97%) of wild recruits vs HB counterparts. Nursery rearing of 64 thousand early juvenile sandfish in floating net cages recorded 16% mean survival; 8.7 thousand of which were released in pens, and consequently 1.1 thousand have

been released in sea ranch. Abalone and sandfish gleaned by fisherfolks in areas outside the release site increased. In preparation for a hatchery, abalone spawning was demonstrated to members of the Molocaboc Sea Ranchers Association (MOSRA). CBRE replicate sites are planned for 2017.

### **Promotion of resource enhancement of seahorses**

Trials on transport and acclimation strategies were conducted on three batches of juvenile seahorses. The optimum stocking density for seahorse juveniles is 3 individuals/L at 12 hours transport duration. The monthly monitoring of seahorses showed there was an increase in number of wild seahorses in this year. Mature male and female seahorses are present all year round. Fisherfolk organization members were trained on the proper handling of live seahorses and seahorse biology. Information, education and communication (IEC) was conducted by giving lectures on the biology, resource management and baseline data of wild seahorse population in Molocaboc Island to elementary school students, fishermen organization members and elementary school teachers.

## **Capacity building programs**

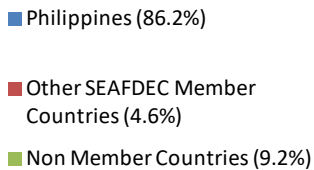
**The International Training Course on Marine Fish Hatchery** was conducted at AQD's Tigbauan Main Station from June 13 - July 19, 2016. There were five (5) participants in the training and of these, three (3) were awarded GOJ-TF Training Fellowship Grants: 1 from the Dept. of Fisheries in Thailand; 1 from Bureau of Fisheries and Aquatic Resources, Region 7, and 1 teacher from San Joaquin School of Fisheries in San Joaquin, Iloilo. The two (2) participants from non-SEAFDEC member countries came from Saudi Arabia and Brazil.

**The Community-Based Freshwater Aquaculture (CBFWA) for Remote Areas of Southeast Asia**, was conducted from November 22 to December 1, 2016 in Binangonan Freshwater Station, Binangonan, Rizal. Participatory rapid appraisal of freshwater aquaculture livelihoods were conducted on-site in Sampaloc Lake in San Pablo City. There were four (4) participants and all were awarded GOJ-TF Training Fellowship Grants: 1 from Bureau of Fisheries and Aquatic Resources, Region 1; 1 from Bureau of Fisheries and Aquatic Resources, Cordillera Autonomous Region; 1 from Department of Fisheries Thailand and 1 from the Department of Fisheries Myanmar.

# Training Program

SEAFDEC/AQD continues to organize training courses and internship opportunities to the public to promote sustainable aquaculture technologies and help build the skills and capacities of fishfarmers, government personnel, the academe and other stakeholders.

**86% of training participants came from the Philippines**



—  
23 training courses  
—  
261 total participants  
20 nationalities  
—  
48 interns  
—  
178 on-the-job trainees  
32 schools  
—



Trainees on marine fish hatchery pose with an anaesthetized seabass breeder after cannulation to check for sexual maturity

## Regular Training Courses

Course, date, venue	Total participants (male+female) Age range	Countries represented by participants
<b>Training Course on Tilapia Hatchery and Grow-out Operations</b> 14 - 18 March (BFS, Binangonan, Rizal)	6 (3F + 3M) 25-39 years old	India: 2 Philippines: 4
<b>Training Course on Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery &amp; Management</b> 22 April - 06 May (TMS, Tigbauan, Iloilo)	7 (1F + 6M) 25-53 years old	Iran: 1 Kiribati Island: 2 Maldives: 3 Mauritius: 1
<b>Training Course on Mangrove Crab Hatchery &amp; Nursery Operations</b> 11 May - 01 June (TMS, Tigbauan, Iloilo)	15 (1F + 14M) 26-66 years old	Germany: 1 Philippines: 13 Singapore: 1
<b>Training Course on Freshwater Prawn Hatchery and Grow-out Operations</b> 16 - 20 May (BFS, Binangonan, Rizal)	10 (2F + 8M) 26-66 years old	Philippines: 10
<b>Training Course on Tilapia Hatchery and Grow-out Operations</b> 06-10 June (BFS, Binangonan, Rizal)	4 (M) 30-56 years old	Bangladesh: 1 Kuwaiti: 1 Philippines: 1 Singapore: 1
<b>Training Course on Mangrove Crab Nursery &amp; Grow-out Operations</b> 13 - 22 June (TMS, Tigbauan, Iloilo)	12 (4F + 8M) 21-59 years old	Philippines
<b>Training Course on Marine Fish Hatchery</b> 13 June - 19 July (TMS, Tigbauan, Iloilo)	5 (2F + 3M) 31-55 years old	Brazil: 1 Philippines: 2 Sudan: 1 Thailand: 1
<b>Training Course on Abalone Nursery &amp; Grow-out</b> 04 - 08 July (TMS, Tigbauan, Iloilo)	5 (2F + 3M) 20-56 years old	Philippines
<b>Distance Learning Course on Principles of Aquaculture Nutrition (AquaNutrition Online)</b> 01 August - 31 October (TMS, Tigbauan, Iloilo)	12 (7F + 5M) 19-44 years old	Bahamas: 1 Peru: 1 Philippines: 7 Singapore: 3
<b>Training Course on Seaweed Farming</b> 12 - 23 September (TMS, Tigbauan, Iloilo)	7 (M) 25-31 years old	Philippines: 1 Sri Lanka: 4 Thailand: 2
<b>Training Course on Catfish Hatchery &amp; Grow-out Operations</b> 19-23 September (TMS, Tigbauan, Iloilo)	3 (1F + 2M) 27-57 years old	Pakistan: 1 Philippines: 2
<b>International Training Course on Community- Based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia</b> 22 November- 01 December	4 (1F + 3M) 26-43 years old	Myanmar: 1 Philippines: 2 Thailand: 1



BFAR personnel prepare oysters for spawning during a *Training Course on Oyster Seed Production, Nursery & Grow-out*



Trainees observe feed preparation during the *Training Course on Mangrove Crab (Mud Crab) Hatchery and Nursery Operations*



Catfish induced to spawn by hormone injection during a *Training Course on Catfish Hatchery & Grow-out Operations*



A lesson on different crab species during a *Training Course on Aquaculture Technologies* held in Tacloban, Leyte



Scaling up of phytoplankton culture during a *Training Course on Marine Fish Hatchery*



Trainees stock grouper fingerlings in cages during a *Training Course on Grow-out Culture of Grouper* held in Pilar, Capiz



## Specialized Training Courses

Course, date, venue	Total participants (male+female) age range	Countries represented by participants
<b>Training Course on Grouper Hatchery</b> 28 March - 03 April (TMS, Tigbauan, Iloilo)	13 (8F + 5M) 21-42	Philippines
<b>Training Course on Grow-out Culture of Grouper</b> 30 - 31 May (Brgy. Binaobaowan, Pilar, Capiz) <i>Funded by Swiss Church Aid – Task Force Mapalad</i>	11 (7F + 4M) 26-59 years old	Philippines
<b>Training Course on Oyster Culture</b> 03-04 June (Pan-ay, Capiz) <i>Funded by Swiss Church Aid – Task Force Mapalad</i>	39 (32F + 7M) 23-61 years old	Philippines
<b>Training Course on Aquaculture Technologies Module 1: Milkfish &amp; Mangrove Crab</b> 31 August - 02 September (Brgy. Old Kawayan, Tacloban City, Leyte) <i>Funded by NGO's for Fisheries Reform, Inc.</i>	23 (8F + 15 M) 21-76 years old	Philippines
<b>Training Course on Aquaculture Technologies Module 2: Oyster &amp; Seaweed</b> 31 August - 02 September (Brgy. Old Kawayan, Tacloban City, Leyte) <i>Funded by NGO's for Fisheries Reform, Inc.</i>	11 (9F + 2M) 21-62 years old	Philippines
<b>Training Course on Mangrove Crab Hatchery &amp; Nursery Operations (Session 2)</b> 19 September - 10 October (TMS, Tigbauan, Iloilo)	8 (2F + 6M) 27-73 years old	Papua New Guinea: 1 Philippines: 7
<b>Training Course on Oyster Seed Production, Nursery &amp; Grow-out</b> 03 – 06 October (TMS, Tigbauan, Iloilo) <i>Funded by BFAR</i>	25 (14F + 11M) 20-60 years old	Philippines

Course, date, venue	Total participants (male+female) age range	Countries represented by participants
<b>Training Course on Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery &amp; Management (Session 2)</b> 21 October - 04 November (TMS, Tigbauan, Iloilo)	2 (M) 31-34 years old	Canada: 1 Tanzania: 1
<b>Training Course on Mangrove Crab Nursery &amp; Grow-out Operations (Session 2)</b> 24 - 31 October (TMS, Tigbauan, Iloilo)	8 (4F + 4M) 22-71 years old	Philippines: 6 Singapore: 2
<b>Training Course on Seaweed Culture</b> 21-22 December (Culasi, Antique) <i>Funded by INSOL Development Foundation, Inc.</i>	31 (23F + 8M) 28-59 years old	Philippines

## Internship and On-the-job-training

Course, date, venue	Total participants (male+female) age range	Countries represented by participants
<b>Internship</b> at AQD hatcheries, laboratories and stations	48 (10F + 38M) 17-59 years old	Philippines
<b>On-the-job-trainings</b> a requirement in academic institutions	178 (121F + 57M) 15-37 years old	Philippines: 171 South Korea: 4 Thailand: 3



On-the-job trainees attend and participate in a series of lectures on aquaculture technologies

# Information Dissemination and Public Awareness

SEAFDEC/AQD strives to reach its stakeholders in the academe, private sector, and the general public by publishing a combination of technical and farmer-friendly publications, maintaining an informative website, and taking part in events and exhibitions. FishWorld, SEAFDEC/AQD's museum-visitor center receives thousands of visitors annually and promotes science and environment education.

—  
27 science papers in journals  
and proceedings

—  
2 proceedings  
1 extension manual  
1 poster  
5 brochures  
6 newsletter issues

—  
60,125 unique website visitors  
291,742 page views

—  
1,125,773 downloads from  
Institutional Repository

—  
7 exhibitions with  
21,278 visitors

—  
23,388 logged visitors to  
SEAFDEC/AQD facilities



Visitors look on as milkfish eggs are shown to them at SEAFDEC/AQD's Integrated Fish Broodstock and Hatchery Demonstration Complex

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## Science Papers in Journals and Proceedings

- Altamirano JP, Recente CP, Rodriguez JC Jr. 2017. Substrate preference for burying and feeding of sandfish *Holothuria scabra* juveniles. *Fisheries Research* 186:514-523 (Special Issue).
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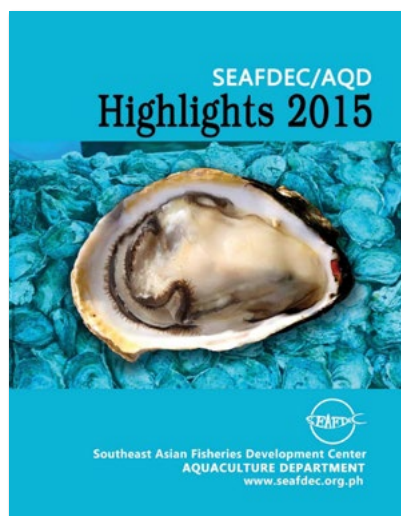
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Substitutes in Aquaculture Feed Formulation. 9-11 December 2014; Nay Pyi Taw, Myanmar; Jakarta, Indonesia: Association of Southeast Asian Nations: Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department; Myanmar, Department of Fisheries (Myanmar); Japan: Government of Japan Trust Fund: pp. 97-104. (review) of Japan Trust Fund: pp. 97-104. (review) of Japan Trust Fund: pp. 97-104. (review)

## Publications

### Annual Report

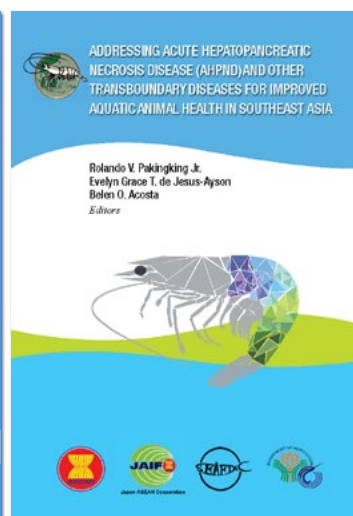


*Highlights 2015* is SEAFDEC/AQD's annual report updating on its accomplishments and progress for the year 2015

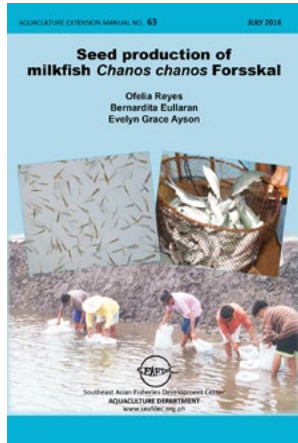
### Conference Proceedings



*Proceedings of the ASEAN RTC on Development and Use of Alternative Dietary Ingredients or Fish Meal Substitutes in Aquaculture Feed Formulation* (left) and *Proceedings of the ASEAN RTC on EMS/AHPND and Other Transboundary Diseases for Improved Aquatic Animal Health in Southeast Asia* (right)

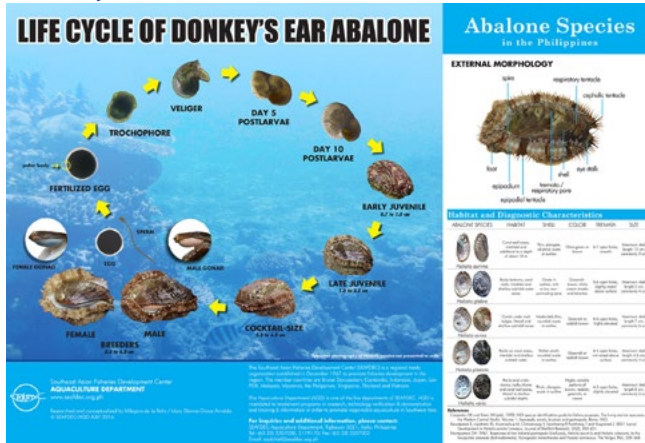


## Extension Manual



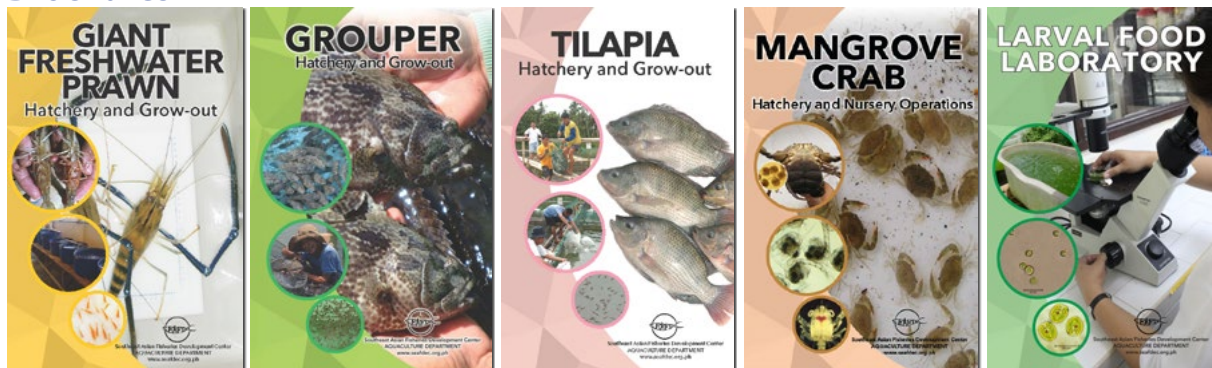
Seed production of milkfish *Chanos chanos Forsskal* (AEM 63) includes topics on site selection, hatchery design, spawning, larval rearing and natural food production

## Life Cycle Poster



This poster on the Life Cycle of Donkey's Ear Abalone illustrates the various stages in the life cycle of *Haliotis asinina* which SEAFDEC/AQD completed in 1997. It also provides comparative information on the five species of abalone that are found in the Philippines

## Brochures



A series of commodity brochures on giant freshwater prawn, grouper, tilapia, mangrove crab that summarizes AQD's technologies for hatchery, nursery, and grow out. A brochure on larval food provides information on AQD's phytoplankton starters and procedures for scaling up microalgal cultures

## Newsletter

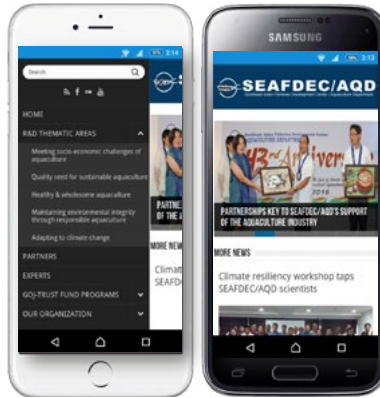


Six issues of AQDMatters, the newsletter of SEAFDEC/AQD, continued to update on the latest activities at the department

# Internet and Media

## SEAFDEC/AQD Website

This year, the SEAFDEC/AQD website ([www.seafdec.org.ph](http://www.seafdec.org.ph)) adopted a new responsive design with a layout that is “mobile friendly” and adjusts to the screen size of various devices. The content was regularly updated with the latest news and developments. The website logged a total of 60,125 unique visitors, generating 291,742 page views. Most visitors (66%) accessed from the Philippines.



The website received a new responsive design that allows it to adjust to the screen size of various devices



Visitors to the SEAFDEC/AQD website ([www.seafdec.org.ph](http://www.seafdec.org.ph)) by country

An integral part of SEAFDEC/AQD's website is the Institutional Repository ([repository.seafdec.org.ph](http://repository.seafdec.org.ph)) which enhances the dissemination of researchers' in-house and external publications. The repository dramatically enhanced accessibility of publications and the visibility of SEAFDEC/AQD. For 2016 alone, the repository had 823,834 searches performed and 1,125,773 PDFs downloaded.

## Public Media

This year, SEAFDEC/AQD made numerable appearances in newspapers, magazines, reputable websites, and television. Notable appearances include the following:

### Philippine Daily Inquirer

To sustain both the ocean and people *by Michael Fabinyi et al.* (13 December 2016, page A12)

### The Philippine Star

Technical congress renames mud crab as mangrove crab (31 January 2016, page B-4)

Reigniting growth in Phl seaweed industry *by Louise Maureen Simeon* (03 April 2016, on page B-5)

De Venecia makes strides in



He said that to enliven the aquaculture industry not only in Aklan but in other parts of the country, the government should make use of the SEAFDEC or the Southeast Asia Fisheries Development Centre in Iloilo.





aquaculture *by Eva Visperas and Cesar Ramirez* (11 December 2016, page B-4)

### Manila Bulletin

How to spend five days in Panay Island (without going to Boracay) *by Samantha Isabel Coronado* (21 February 2016, page H1)

### Agriculture Magazine

Not 'Mud' Anymore : The 'Alimango' has a new name *by Julio P. Yap, Jr.* (March 2016, page 46)

Innovative aqua technologies from PCAARRD *by Dr. Rafael D. Guerrero III* (May 2016, page 28-29)

Technology breakthroughs featured at forum *by Rose Anne K. Manangbaya, DOST-PCAARRD S&T Media Service* (June 2016, page 26, 27)

Saving the milkfish industry through local production of hatchery-bred fry (August 2016, page 20-22)

### Biolife

Biotechnology vital in developing feed ingredients for sustainable aquafeed industry *by Joel C. Paredes* (Issue 1, 2016, page 22-24)

The milkfish at SEAFDEC (Issue 1, 2016, page 25)

SEAFDEC sprints to enhance seaweed industry (Issue 1, 2016, page 26-27)

### Hatchery International

Wanted in the Philippines: More mud crab hatcheries to sustain the "sunshine industry" *by Ruby Gonzalez* (May/June 2016, page 15)

### Social Media

Squandered aqua potentials lamentations of a fisherman *by Manny Pinol* (29 May 2016, [https://www.facebook.com/permalink.php?story\\_fbid=1030856833663452&id=351448724937603](https://www.facebook.com/permalink.php?story_fbid=1030856833663452&id=351448724937603))

### Television

TV guesting at "Sikat ka Iloilo" program of ABS-CBN Regional Network to promote anniversary activities; 6 July 2016

SEAFDEC/AQD featured in "Mag-TV na Amiga" program of ABS-CBN Regional Network; 10 July 2016

Farmers Forum anniversary activity featured during the "TV Patrol Panay" program of ABS-CBN Regional Network; 14 July 2016

## Fairs and Exhibits

Exhibition or Event	Date	Venue
<b>1<sup>st</sup> Bangus Congress</b>	03-05 February	Pasay City
<b>Strategic Industry S&amp;T Programs for Agri-Aqua Growth (SIPAG)</b>	02-04 March	Los Baños, Laguna
<b>1<sup>st</sup> National Aquaculture Summit</b>	07-08 July	Dagupan City
<b>5<sup>th</sup> Aquamarine Expo</b>	15-17 July	Quezon City
<b>7<sup>th</sup> Aquatech: Aquaculture Expo &amp; Convention Philippines</b>	20-21 July	Tagaytay City
<b>National Science and Technology Week</b>	25-29 July	Los Baños, Laguna
<b>Agrilink/Foodlink/Aqualink 2016</b>	06-08 October	Pasay City
<b>3<sup>rd</sup> Iloilo Biodiversity and Watershed Week</b>	21-25 November	Iloilo City
<b>Philippine Seaweed Convention</b>	23-25 November	Cebu City



1st Bangus Congress



Strategic Industry S&T Programs for Agri-Aqua Growth (SIPAG)



1st National Aquaculture Summit



7th Aquatech: Aquaculture Expo & Convention Philippines



National Science & Technology Week



Agrilink/Foodlink/Aqualink 2016

# FishWorld

SEAFDEC/AQD's museum and visitor center continued to promote science and environment education to students through competitions and internships. Science-art contests organized as part of the celebration of Aquaculture Week gathered 200 students from 11 high schools and 23 elementary schools from around

Panay Island. The annual summer internship programs on aquatic biodiversity for high school students catered to 11 students from 2 science high schools.

FishWorld also has a longstanding work on endangered megafauna. This year 22 more megafauna

(14 green turtles, 7 olive ridleys, 1 hawksbill) have been documented.

The FishWorld collection now stands at around 5000 species, with the recent ones coming from Davao Gulf and Sarangani Bay, plus around 70 species in a live exhibit of aquatic organisms.



Biodiversity-themed songs and dance contest



Seafood preparations by high school students



Ocean literacy lecture contest



Interns take part in the release of sea turtles



Students from various schools listen to lectures



The Philippine Coast Guard assisting in the release of turtles

# Services

Several facilities operate in support of the research and development activities of SEAFDEC/AQD. These facilities are likewise availed by the private sector, the academe and government.

The Larval Food Laboratory and Feed Mill provide for the nutrition of aquaculture commodities grown in various hatcheries and grow-out facilities. The Laboratory Facilities for Advanced Aquaculture Technologies conducts proximate, water, soil and microbiological analysis. The Fish Health Section handles diagnostic cases for a range of viruses, bacteria and parasites.

134 million milkfish fry

80 tons of aquafeed produced

40,834 liters of microalgal and rotifer starters

18 tons of market-sized commodities

4,497 samples analyzed

340 diagnostic cases



The Integrated Milkfish Broodstock and Hatchery Techno Demonstration Complex in Tigbauan

## Larval Food Laboratory

To support the research and production activities of AQD, the larval food laboratory served 36,765 liters of microalgal (live and paste) and rotifer starters along with 17.52 kg (wet weight) of *Artemia* biomass. The laboratory also catered to 101 clients from the private sector (local, 39%; foreign, 11%), academe (41%), and government institutions (9%). The items sold included 4,069 liters of liquid microalgal/rotifer/starters, 120g *Artemia* cysts, 18.4 kg of concentrated microalgal paste, 50 tube cultures, and pre-mixed fertilizers and culture media (104 liters TMRL, 243.6 liters F medium and 43.4 liters Conwy medium).

## Feed Mill

The Feed Mill produced over 80 tons of various types of feed for 2016, mostly for milkfish (64%). About 23% of the output were produced for the private sector, while the rest were for the research activities of AQD.

Phytoplankton species make up of liquid microalgal and rotifer starters produced in the Larval Food Laboratory of SEAFDEC/AQD in 2016

Species	Percent
<i>Skeletonema tropicum</i>	20.98
<i>Nanochlorum</i> sp.	14.91
<i>Chaetoceros calcitrans</i>	31.19
<i>Brachionus rotundiformis</i>	5.79
<i>Tetraselmis tetrathele</i>	1.97
<i>Chlorella sorokiniana</i>	0.56
<i>Navicula ramossissima</i>	0.58

Species	Percent
<i>Thalassiosira</i> sp.	0.62
<i>Amphora ramossissima</i>	0.25
<i>Chaetoceros gracilis</i>	0.22
<i>Leptolyngbia</i> sp.	0.09
<i>Nitzschia</i> sp.	0.14
<i>Rhodomonas</i> sp.	0.10
<i>Isochrysis galbana</i>	22.50
<i>Chaetoceros muelleri</i>	0.01

Aquafeed produced at the SEAFDEC/AQD Feed Mill in 2016

Feed Type	Volume (kg)		
	SEAFDEC/AQD	Private Sector	Total
Abalone	10		10
Catfish larval	5		5
Grouper			
• Broodstock	500	2,875	3,375
• Larval	105		105
• Grow-out	700	200	900
Milkfish			
• Broodstock	9,785	12,460	22,245
• Larval	133	58	191
• Grow-out	6,682	0	6,682
• Experimental	22,153	4	22,157
Mud crab	510	553	1,063
Pompano	25		25
Seabass broodstock	200		200
Shrimp	1,953	2,149	4,102
Siganid broodstock	315		315
Snapper	1,000		1,000
Tilapia broodstock	200	1	201
High-value species	17,195	200	17,395
Feed ingredients	389	200	589
<b>TOTAL</b>	<b>61,860</b>	<b>18,700</b>	<b>80,560</b>

## Hatchery and Grow-out Production

Milkfish continued to top SEAFDEC/AQD's hatchery production, producing over 130 million larvae and almost 9 million fry. Sales of over 4 million bighead carp fry are also notable.

Almost 18 tons of market-size commodities were produced in 2016 with milkfish also topping the list at 13 tons followed by pompano at almost 3 tons. Also produced were 4,665 pieces of soft-shelled mangrove crabs. These are produced as byproduct of different research and technology verification and demonstration activities.



Market-sized milkfish, freshly harvested from the Igang Marine Station

SEAFDEC/AQD's hatchery production in 2016 by commodity

Commodity	Quantity (pcs)	
	larvae	fry
Milkfish	134,479,839	8,964,610
Grouper		
<i>E. coioides</i>	5,021,670	4,061
<i>E. fuscoguttatus</i>	59,971,918	75
Rabbitfish	10,901,627	242,832
Sea bass	31,211,317	208,600
Snapper	7,408,877	124,800
Pompano	1,884,538	458,520
Bighead carp		4,445,600*
Tilapia		73,560*
	megalopae/crab instar	juveniles
Mangrove crab	831,911	
Abalone		64,460
	postlarvae/juveniles	
Giant freshwater prawn		30,253*

\*based on sales data

Market-sized commodities produced by SEAFDEC/AQD in 2016

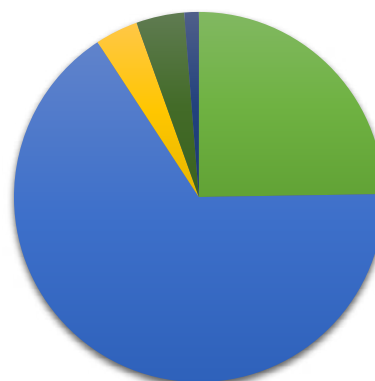
Commodity	Quantity (kg)
Milkfish	13,042
Pompano	2,753
Snapper	775
Grouper	512
Tilapia	288
Mangrove crab	373
Seabass	46
<i>P. indicus</i> (Shrimp)	42
Catfish	17
Abalone	13
Soft-shelled crabs (pcs)	4,665

## Laboratory Analytical Services

SEAFDEC/AQD's Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT), accepted for analysis a total of 4,497 samples (or 5,456 determinations) the bulk of which came from SEAFDEC/AQD research studies and a few from the private sector or the academe.

Some 1,113 of these samples were for proximate analyses for crude protein, crude fat, crude fiber, calcium, phosphorus, moisture, and ash; 40 for fatty acid profile; 2,969

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; 169 for soil analyses for pH, organic matter, available Fe/S/P, and CNS; 189 microbiological analyses for APC, Salmonella, Shigella, Staphylococcus aureus, coliform, Escherichia coli, Vibrio, yeast & mold, and water potability; and 2 for scanning & transmission electron microscopy.



Legend for Laboratory Analytical Services pie chart:  
 Proximate (25%)    Water (66%)  
 Soil (4%)    Microbiological (4%)  
 Others (1%)

Samples accepted for various analyses at the Laboratory Facilities for Advanced Aquaculture Technologies in 2016

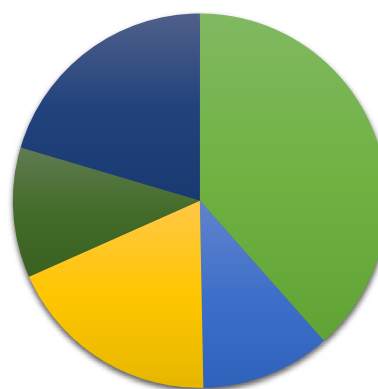
## Diagnostic Services

The Fish Health Laboratory handled a total of 340 diagnostic cases, mostly on shrimp (38%).

Diagnostic cases included detection of WSSV (134 of 474 samples positive), IHNV (30 of 389 samples positive), IMNV (0 of 15 samples positive), TSV (0 of 15 samples positive), YHV/GAV (0 of 17 samples positive), AHPND (108 of 215 samples positive), EHP (0 of 2 samples

positive), VNN (1 of 30 samples positive), RSIV (0 of 5 samples positive), MBV (2 of 19 samples positive), and parasites (6 of 6 samples positive). Bacterial count was also done for 198 samples and bacterial identification for 20 samples.

The Microtechnique Laboratory released 1,601 slides for the 1,225 samples received both for research and diagnostic services.



Legend for Diagnostic Services pie chart:  
 Shrimp (38%)    Fish (11%)  
 Crab (19%)    Water (11%)  
 Others (21%)

Diagnostic cases examined at the Fish Health Laboratory in 2016

# Human Resources and Finance

Various avenues were provided to enhance the capacity and promote the productivity of 268 total SEAFDEC/AQD personnel who are behind the activities and accomplishments of the organization. Sound management of fiscal resources, this year contributed mostly by the Philippine Government, is imperative to maximize the output of activities and their benefit to stakeholders.

—  
268 total personnel  
(89 regular, 78 fixed-term)  
as of end 2016  
—

—  
5.5-million USD in grants and  
other income  
—

—  
80% of funds came from the  
Philippine Government  
—

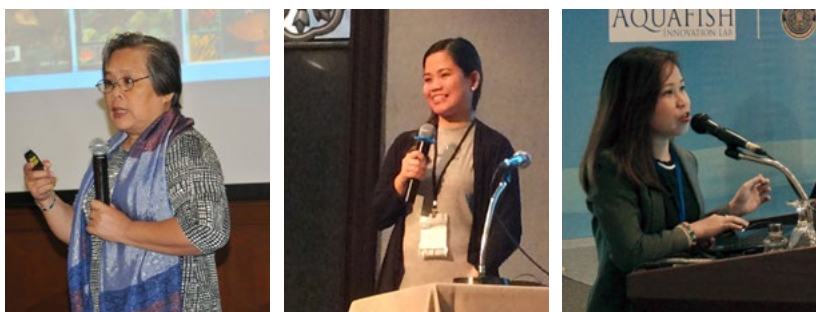


SEAFDEC/AQD personnel pose for a group photo during the 43rd anniversary opening ceremonies.



## Staff Development

Support was provided for the attendance and participation of qualified and deserving staff in local and international meetings and conferences. SEAFDEC/AQD's Staff Development Program aims to enhance and upgrade the knowledge and skills of research, information, and administrative personnel.



(From left ) Dr. TU Bagarinao presents her paper on mollusk diversity at AQD stations during the World Congress for Malacology; RS Taan presents her paper on the use of *Ulva pertusa* meal as diet for abalone during the Asia-Pacific Conference on Algal Biotechnology; JG Suyo presents her paper on gender, resource use and coastal management during the Asian Fisheries and Aquaculture Forum; .

List of meetings and conferences attended by beneficiaries of the Staff Development Program

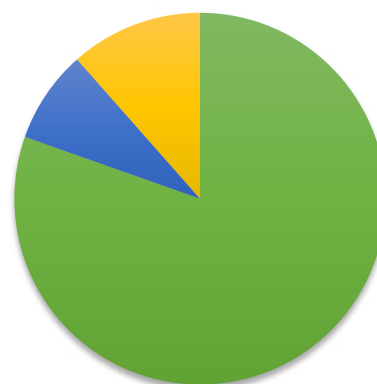
Event	Date	Location
31st Philippine Chemistry Congress	13-15 April 2016	Iloilo City, Philippines
Asian Pacific Aquaculture 2016	26-29 April 2016	Surabaya, Indonesia
8th Secretaries and Administrative Professionals Summit	5-6 May 2016	Pasig City, Philippines
70th Psychological Society of America Annual Conference	24-28 July 2016	Cleveland, Ohio, USA
11th Asian Fisheries and Aquaculture Forum (AFAF)	03-07 August 2016	Bangkok, Thailand
World Congress of Malacology	18-24 July 2016	Penang, Malaysia
Supervision: A Key to Greater Productivity in Workplace & Self-empowerment: A Foundational Seminar on Work Values	08-10 September 2016	Iloilo, Philippines
2-day seminar on "Practices and Challenges Toward Sustainability in Laboratory Management"	29-30 September 2016	Quezon City, Philippines
16th World Lake Conference	07-11 November 2016	Bali, Indonesia
9th Asia-Pacific Conference on Algal Biotechnology (APCAB)	15-18 November 2016	Bangkok, Thailand
2nd National Fisheries Biotechnology Symposium	24-25 November 2016	Nueva Ecija, Philippines
71st Philippine Institute of Certified Public Accountants (PICPA) Annual National Convention	24-26 November 2016	Davao City, Philippines
2016 Philippine Society for Microbiology (PSM) Visayas Annual Meeting and Regional Convention	08-09 December 2016	Iloilo City, Philippines

# Finance

STATEMENT OF FINANCIAL POSITION (US Dollar '000)		
	As of Dec. 31, 2016	As of Dec. 31, 2015
<b>ASSETS</b>		
<b>CURRENT ASSETS</b>		
Cash and cash equivalents	2,157	1,894
Accounts Receivables	508	475
Materials and Supplies	56	71
Other current assets	1	1
<b>Total Current Assets</b>	<b>2,722</b>	<b>2,441</b>
<b>NON-CURRENT ASSETS</b>		
Cash investments	253	267
Other non-current assets	201	259
<b>Total Non-current Assets</b>	<b>454</b>	<b>526</b>
<b>TOTAL ASSETS</b>	<b>3,176</b>	<b>2,967</b>
<b>LIABILITIES</b>		
<b>CURRENT LIABILITIES</b>		
Accounts Payable	610	1,048
Funds Held-in-Trust	193	239
<b>TOTAL LIABILITIES</b>	<b>803</b>	<b>1,287</b>
<b>NET ASSETS</b>		
Designated	2,373	1,680
Undesignated	-	-
Unrealized Gain on AFS	-	-
Financial Assets	-	-
<b>TOTAL NET ASSETS</b>	<b>2,373</b>	<b>1,680</b>
<b>TOTAL LIABILITIES AND NET ASSETS</b>	<b>3,176</b>	<b>2,967</b>

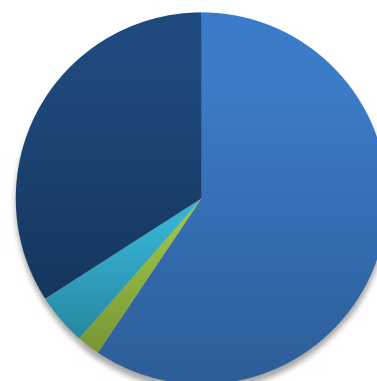
STATEMENT OF REVENUES & EXPENDITURES (US Dollar '000)		
	Period ending Dec. 31, 2016	Period ending Dec. 31, 2015
<b>REVENUES</b>		
Contributions / Grants	5,059	4,587
Other Income	445	578
<b>TOTAL REVENUE</b>	<b>5,504</b>	<b>5,165</b>
<b>EXPENDITURES</b>		
Research Programs	2,801	3,266
Training Programs	95	135
Information Programs	212	204
General Administrative and Non-Project Expenses	1,606	2,029
<b>TOTAL EXPENDITURES</b>	<b>4,714</b>	<b>5,634</b>
<b>BALANCE</b>	<b>790</b>	<b>(469)</b>

## Sources of Funds



- Government of the Philippines (80%)
- Internally-generated Income (8%)
- External Grants (12%)

## Allocation of Funds



- Research Programs (59%)
- Training Programs (2%)
- Information Programs (5%)
- General Administrative and Non-Project Expenses (34%)

# 2016 Heads of Offices

## Management Group

Acting Chief/Deputy Chief Dr. Chihaya Nakayasu  
Head, RD Dr. Evelyn Grace Ayson  
Head, TVDD Dr. Fe Dolores Estepa  
Head, TID Dr. Ma. Junemie Hazel Ramos  
Head, AFD Ms. Jasmine Gelvero

## Station Heads/OIC

OIC, BFS Dr. Maria Lourdes Aralar  
Head, DBS Dr. Emilia Qunitio  
OIC, IMS Mr. Mateo Paquito Yap  
OIC, Manila Office Dr. Maria Rowena Eguia

## Program Leaders

Producing quality seed for sustainable aquaculture Dr. Maria Rowena Eguia  
Promoting healthy and wholesome aquaculture Dr. Mae Catacutan and Dr. Rolando Pakingking Jr.  
Maintaining environmental integrity through responsible aquaculture Dr. Maria Lourdes Aralar  
Meeting social and economic challenges in aquaculture Dr. Nerissa Salayo  
Regional programs Dr. Chihaya Nakayasu

## Section Heads/OIC

### *Research Division*

Breeding and seed production Ms. Milagros dela Peña  
Fish health Dr. Rolando Pakingking Jr.  
Nutrition and feed development Dr. Mae Catacutan  
Farming systems and ecology Ms. Maria Rovilla Luhan  
Socioeconomics Dr. Nerissa Salayo

### *Technology Verification and Demonstration Division*

Technology verification Ms. Sheryll Avanceña  
Demonstration and packaging Dr. Fe Dolores Estepa

### *Training and Information Division*

Training Mr. Caryl Vincent Genzola  
Development communication Mr. Rex Delsar Dianala  
Library and databanking services Mr. Stephen Alayon

### *Administration and Finance Division*

Engineering Engr. Zaldy Suriaga  
Human resources management Ms. Nira Grace Llona  
Budget-cashiering Ms. Jiji Rillo  
Accounting Ms. Jasmine Gelvero

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



SEAFDEC/AQD's Dumangas Brackishwater Station



**AQUACULTURE DEPARTMENT**  
Southeast Asian Fisheries Development Center  
[www.seafdec.org.ph](http://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.

