SEAFDEC/AQD

Highlights 2018

Southeast Asian Fisheries Development Center
Aquaculture Department
ANNUAL REPORT

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COVER
Philippine map: Proposed hatchery sites assessed by the feasibility study team of SEAFDEC/AQD in 2018.
Three-layer illustration: The three main steps in the conduct of feasibility study. The bottom layer represents the evaluation of the pre-identified site thru satellite imagery and site visit. The middle layer is the creation of the feasibility study, mainly the engineering and architectural design of the multi-species hatchery. The top layer represents the packaged and finished feasibility study.

Tiger shrimp, *Penaeus mondon*, displayed at the Aquaculture Week 2018 exhibition

Message of the Chief

This year has been very interesting and challenging for SEAFDEC/AQD because we always had to be on our toes in order to respond to challenges and produce results.

Early on, we were challenged by our host, the Philippine Government, to produce sufficient fish to feed over 100 million Filipinos, without relying on imported seed. On top of this, we were also tasked to take on a major role in the establishment of legislated multi-species hatcheries in different sites around the Philippines.

In response, we have taken serious steps to improve our milkfish fry production. Since June, our Igang Marine Station was entirely dedicated to research and production activities to ensure the uninterrupted spawning of our breeders. We also acquired additional milkfish broodstock, which arrived in November, to augment the more than 300 already in our care.

Our team has also been busy trekking remote rugged roads to study the feasibility of proposed sites for multi species hatcheries. In all, we visited 15 legislated areas and assessed 29 proposed sites. From these, we found 10 areas have the necessary criteria to host a hatchery. In September, our design of hatcheries for two sites in Caraga Region were completed and turned over to the local government units.

To develop a critical mass of aquaculturists, some of whom will eventually be fielded to the legislated hatcheries, we conducted a manpower development training on the culture of shrimp, marine fish, and tilapia. We sponsored the training of 19 fisheries and aquaculture graduates from state universities and colleges who underwent intensive training for two months.

Towards reviving the tiger shrimp industry, through our banner program "Oplan Balik Sugpo," we have completed the rehabilitaton and reconfiguration of our hatchery in the Tigbauan main Station and grow-out ponds in Dumangas Brackishwater Station. The hatchery has already produced quality and pathogen-free fry which are ready for grow-out demonstration.

Thirty-two studies were conducted this year in line with our mandate to conduct scientific research. Through these, our researchers continue to generate aquaculture technologies and information in priority areas of broodstock development and seed production, farming systems and ecology, nutrition and feed development, fish health management, and socioeconomics. These, in turn, fuel our information dissemination efforts through various trainings and information materials.

The year 2018, tough and challenging as it was as we sowed the seeds of development, is only the beginning. I look back with pride in what SEAFDEC/AQD has accomplished, knowing that bountiful harvests await in the coming years. Meanwhile, we will be relentless in pressing toward our mission of ensuring there will be enough fish and livelihood for the generations to come.

Dan D. Baliao
Chief, SEAFDEC/AQD

The Chief visits proposed hatchery sites

Highlights of the Year 2018


MEMORANDUM OF AGREEMENT

KNOW ALL MEN BY THESE PRESENT:

This MEMORANDUM OF AGREEMENT is entered into by and between:

The **BUREAU OF FISHERIES AND AQUATIC RESOURCES (BFAR) Central Office**, a duly constituted agency of the Department of Agriculture with office address at PCA Compound, Elliptical Road, Visera, Diliman, Quezon City, represented herein by its National Director, **COMMODORE EDUARDO D. GONGONA, PCG (Ret)** and herein referred to as **"BFAR-CO"**,

and

The **SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER AQUACULTURE DEPARTMENT**, a regional treaty organization established in 1973 mandated to undertake aquaculture research and development, with main station in Tigbauan, Iloilo, represented by its Chief, **MR. DAN BALIAO**, duly authorized for this purpose, and hereinafter referred to as **"SEAFDEC/AQD"**.

WITNESSETH

WHEREAS, **BFAR** is the primary agency of the government mandated to conserve, protect, and sustain management of the fishery and aquatic resources of the country, charged with the responsibility of transferring to the fisherfolk the appropriate technologies developed by national and international research institutions to primarily increase aquaculture production and generate jobs in the countryside,

8 February

P10-M agreement sealed for planning of 15 hatcheries

story on page 55

13 July

Database on alternative feed ingredients launched

story on page 35

1 April

Dr. Mori is new deputy chief

story on page 62

13 July

Aquatic news index launched

story on page 49

10 April

TVDD becomes TVED as extension gains more focus

story on page 67

13 July

Digital libraries distributed to colleges and universities

story on page 49

7 May

BFAR turns over biotech facilities to SEAFDEC/AQD

story on page 66

20-22 August

RTC on aquatic emergency preparedness

story on page 19

13 July

Buildings named after prime movers

story on page 66

28 September

Turn-over of first two hatchery feasibility studies

story on page 56

Research & Development Programs in 2018

THEMATIC PROGRAMS

	Study Title	Main Proponent	Collaborating Partners
Quality Seed for Sustainable Aquaculture			
1	Philippine native catfish (*Clarias macrocephalus*) broodstock development and management: A. Evaluation of reproductive traits for selection and propagation of quality catfish broodstock. B. Development of least cost catfish broodstock maturation diet	MRR Eguia	
2	Domestication of the Philippine native eel *Anguilla* sp. (Teleostei: Anguillidae)	FA Aya	JAIF
3	Breeding and seed production of giant grouper (*Epinephelus lanceolatus*)	EDJ Ayson	ACIAR
4	Effects of water depth, temperature and methyl farnesoate on the mating behavior and reproductive performance of black tiger shrimp (*Penaeus monodon*) broodstock	EG Estante	
5	Refinement of rearing and feeding techniques for sustainable mass production of polychaete *Marphysa* sp.	MAE Mandario	
6	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	JJDC Huervana/ ET Quinitio	DOST-PCAARRD
7	Domestication of silver therapon (*Leiopotherapon plumbeus*) (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	
8	Optimization of electrolytic flocculator for paste production of important locally available microalgae in aquaculture	AV Franco	
9	Use of algal paste in the larval rearing of mangrove crab *Scylla serrata*	JJDC Huervana	
10	Assessment of tank-based nursery system of sandfish *Holothuria scabra*	JP Altamirano	

	Study Title	Main Proponent	Collaborating Partners
11	Developing transport techniques for milkfish, *Chanos chanos*, juveniles	JIL Aquino	
12	Optimizing hatchery production of early juveniles sandfish *Holothuria scabra*	JP Altamirano	
13	Verification of the effectiveness of SEAFDEC/AQD broodstock diets in improving reproductive performance in the tropical abalone, *Haliotis asinina*	JB Biñas	
14	Seed production of mangrove crab (*Scylla serrata*)	JJDC Huervana	
15	Production of *Kappaphycus* plantlets	MRJ Luhan	
16	Large-scale production of donkey's ear abalone, *Haliotis asinina* juveniles	RM Piloton/ DD Catedral/ NC Bayona	
Healthy and Wholesome Aquaculture			
17	Evaluation of raw meal, fermented and live green macroalgae *Chaetomorpha linum* as food source for farmed *Penaeus monodon*	JB Biñas	
18	Evaluation of phytoecdysteroids crude extract from spinach in molting and growth of mangrove crabs, *Scylla serrata*	JIL Aquino	
19	Effect of thraustochytrid on reproductive performance of hatchery-bred abalone, *Haliotis asinina*	REP Mamauag/ RBS Taan/ JB Biñas	
20	Evaluation of protein enhanced copra meal as a dietary protein source for economically important finfish	REP Mamauag	
21	Quantitative amino acid requirements of juvenile Asian sea bass (*Lates calcarifer* Bloch): Requirements for leucine, isoleucine and histidine	REP Mamauag/ RMA Cabrera	
22	Evaluation of milkfish by-product hydrolysate as ingredient in freshwater finfish larvae diets tilapia, *Oreochromis niloticus*	REP Mamauag	
23	Detection, quantification, and viability of Tilapia Lake Virus (TiLV) in pond soil and water as influenced by water quality parameters and culture management	DJC Logronio	
24	Efficacy of different therapeutants against *Caligus* sp. infestation in tropical fish under laboratory conditions	GE Pagador	
25	Development of low-cost diet for milkfish	REP Mamauag	
26	Production of *Penaeus vannamei* using Biofloc System with sludge removal facility (SRF) to demonstrate the productivity of old earthen ponds during the wet season	EG Estante	

	Study Title	Main Proponent	Collaborating Partners
27	Demonstration of grow out techniques of commercially-viable shrimp species (*P. monodon*, *P. vannamei*, *P. indicus*) using SEAFDEC/AQD formulated diet and commercial feed.	REP Mamauag	
28	Hatchery production and semi-intensive pond culture of *Penaeus indicus*	EG Estante/ SS Avanceña	
Maintaining Environmental Integrity through Responsible Aquacuture			
29	Giant freshwater prawn culture in lake-based cages: Strategies to improve production through stock manipulation and management	MLC Aralar	
30	Joint Mission for Accelerated Nationwide Technology Transfer Program for Aquaculture (JMANTTP-II) (Hatchery and grow-out technology for selected finfish, crustacean, mollusc and seaweeds	DD Baliao	BFAR
31	Grow-out culture of abalone in pipes	MJHL Ramos	
32	Polychaete culture in ponds and tanks	VR Alava	
Meeting Social and Economic Challenges in Aquaculture			
33	Assessment of anguillid eel nursery industry in the Philippines and selected Southeast Asian countries	MLC Aralar	JAIF
34	Economic benefits and losses in seaweed farming in Guimaras, Philippines due to some climate change indicators	RJG Castel	

REGIONAL PROGRAMS (GOJ-TRUST FUND)

Reinforcement and optimization of fish health management and effective dissemination in the Southeast Asian Region			
35	Enhancement of vaccine efficacy for the prevention of viral nervous necrosis in high value marine fish	RV Pakingking Jr.	GOJ-TF
36	Establishment of protective measures against persistent and emerging parasitic diseases of tropical fish	GE Pagador	GOJ-TF
37	Application of adjuvants, carriers and RNAi technology to enhance the antiviral immune response of shrimp to WSSV	EC Amar	GOJ-TF
38	Epidemiology of the early mortality syndrome (EMS) in *Penaeus monodon*	EA Tendencia	GOJ-TF
39	Development and acceleration of rapid and effective fish and shrimp health management. Subtitle: Establishment of threshold infection levels of WSSV and VP_{AHPND} in penaeid shrimp	LD de la Peña	GOJ-TF

	Study Title	Main Proponent	Collaborating Partners
Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources			
40	Responsible aquaculture through aquasilviculture	EA Tendencia	GOJ-TF
41	Use of plant-based protein sources in tilapia feeds for improved production traits	FA Aya/ MRR Eguia	GOJ-TF
42	Promotion of resource enhancement of seahorses	SMB Ursua	GOJ-TF
43	Community-based integrated production of abalone *Haliotis asinina* and sandfish *Holothuria scabra* through culture, sea ranching and stock enhancement	ND Salayo	GOJ-TF

SPECIAL PROJECTS

44	Demonstration and verification of sustainable and efficient aquaculture techniques by combination of multiple organisms	M Kodama/ ND Salayo	JIRCAS
45	Development of low fish meal feed for aquaculture using alternative resources	T Sugita	JIRCAS

Abbreviations used

ACIAR	Australian Centre for International Agricultural Research
BFAR	Bureau of Fisheries and Aquatic Resources
DOST-PCAARRD	Department of Science and Technology - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
GOJ-TF	Government of Japan - Trust Fund
JAIF	Japan-ASEAN Integration Fund
JIRCAS	Japan International Research Center for Agricultural Sciences

***Penaeus monodon* broodstock** sourced from Negros Island, used in an experiment on mating behavior.

Quality Seed for Sustainable Aquaculture

A sustainable supply of good quality seedstock is key to a successful aquaculture enterprise. Rearing quality seedstock requires efficient husbandry techniques and suitable farm conditions. With the intensification of aquaculture in Southeast Asia and environmental challenges such as those resulting from climate change, genetic quality and culture management are equally important in ensuring a steady production of good quality seeds and later, marketable aquaculture products.

Development of good quality broodstock

To develop and manage quality broodstock for either commercial fish farming or stock re-population, stock characterization using molecular markers is used to aid in determining the genetic quality of hatchery stocks.

Abalone

This program aimed to generate a preliminary database on possible sources of genetically diverse *Haliotis asinina* stocks for broodstock development. One hatchery-bred stock and nine wildbred stocks from Masbate, Palawan, Pangasinan, Cebu, Sagay, Zamboanga del Sur, Agusan del Norte, Surigao del Sur and Dinagat Island were obtained and analyzed using six novel short tandem repeat markers. Seven of these founder stocks were used to produce F1 batches (mainly families) that were later assessed for genetic variability and growth performance.

Mean expected heterozygosities (He) in the founder stocks ranged from 0.76 to 0.90 where the highest was the Palawan stock and the lowest was noted to be from Zamboanga del Sur followed by those from Sagay at 0.79. Results also revealed that all stocks examined generally have moderately high to high genetic variability. Genetic variability, growth and reproductive performance across stocks were similar, suggesting that abalone from any of the studied sites can be used for local aquaculture. However, to maintain the genetic integrity of wild abalone populations, abalone seedstock production for re-seeding natural populations should use breeders from near the restocking sites.

Finally, to maintain good quality hatchery-produced seedstock, it is suggested that regular monitoring of the growth performance be done on the seedstock when reared in the grow out phase since hatchery-bred stocks' growth appeared to be poor compared to those bred from newly-acquired wild parents. As such, broodstock management through replenishment or replacement of breeders must be made when growth performance is noted to decline.

Abalone breeder feeding on formulated feed

In previous studies on the abalone, broodstock fed formulated diets with higher protein and energy level ratios had better fecundity, shorter time to first spawning, increased spawning frequency, and improved egg hatchability compared to those fed natural food. This year, a study commenced to test the two best performing diets (protein/energy level ratios of 37%/3,570 kcal/kg and 42%/3,750 kcal/kg) involving several batches of breeders. Hatchery-bred F1 juveniles produced from wild-caught broodstock have been grown to a mean shell length of 5-6 cm. After a 2-month conditioning period, these will be fed the formulated diets and their reproductive performance will be monitored.

Mangrove crab

Genetic characterization of *Scylla serrata* stocks based on three novel and three existing short-tandem repeat (STR) markers was done to check for the negative impacts of domestication across several generations of selected and control stocks from Camarines and Surigao Provinces. Raw data based on uncorrected estimates of the number of alleles (*A*) showed that the parental stocks from Camarines and Surigao had 10.17 and 10.33 number of alleles respectively while two batches of the first generation Camarines control stocks were lower at 6.67 and 6.5 respectively and one batch of the first generation Surigao control stock had $A = 6.33$. Slightly lower A estimates

were noted in the first generation selected stocks from Camarines (6.17 and 6.5) and Surigao (4.0). Expected heterozygosity estimates were not significantly different between the stocks and across generations.

Silver therapon

Three broodstock diets with varying levels of dietary protein (30% or 30CP; 40% or 40CP; and 50% or 50CP) were formulated to examine the effect of artificial diets on the reproductive performance of captive silver therapon (*Leiopotherapon plumbeus*) broodstock. The performance of captive broodstock fed a test diet with 50CP and reared using biofloc technology (BFT) was also evaluated.

All females in the 40CP and 50CP groups spawned, whereas only 89% and 78% of females spawned in the BFT-50CP and 30CP groups. Gonadosomatic index (GSI) was highest in female broodstock in the 50CP group (12.53) but was comparable with other treatment groups. Male broodstock in the 40CP group (9.48) showed the highest GSI among all the treatment groups. Relative fecundity (313-390 eggs per gram female), fertilization (68-75%) and hatching rates (48-90%) increased with increasing dietary protein level. High larval production (418-421 larvae per gram female) was observed in the 40CP and 50CP groups.

Sexually mature silver therapon (top) with representative colors of gonad (middle, bottom) fed formulated diets.

Catfish

A study on the Philippine native clariid catfishes (mainly *Clarias macrocephalus* and *C. batrachus*) that focuses on broodstock development and management commenced this year. Stocks from three sources (Zambales, Quezon and Iloilo provinces) were collected for broodstock development and broodstock diet trials. The native catfish were then maintained and bred through induced spawning to comprise the founder stocks. Offspring with known ages produced from each stock were reared for use in 2019 for stock evaluation and comparison looking at possible differences in breeding efficiency and response to broodstock diets.

The broodstock diets that have been tested initially on the Zambales founder stocks contained 0.5% mango peel, 0.5% paprika and a combination of both. Preliminary results using mature *C. batrachus* from Iba, Zambales showed higher relative fecundity from those fed feeds containing either 0.5% mango peel (28.3 eggs/g female body weight) or the combination

of mango peel and paprika (28.6 eggs/g female body weight). However, hatching rate was noted to be higher (86.3%) in the treatment fed the diet with paprika alone.

Tiger shrimp

To best understand conditions that encourage and facilitate mating in the tiger shrimp *Penaeus monodon*, experiments that would determine differences and problems in breeding performance of male and female broodstock from captive and wild environments were conducted. Video documentation on the mating behavior of reciprocally-crossed adult *P. monodon* at different temperature levels and water depth were done. The experiment on the use of methyl farnesoate, a hormone that could induce female crustacean molting and reproduction, will continue in 2019.

Based on video recordings, wild males were observed to spend more time near the wild females compared to captive female broodstock. Likewise, wild males pursued the molted female broodstock more frequently compared to captive males. In terms of molting time, wild female shrimp were observed to molt earlier compared to captive shrimp. The time for females to exit the molt was similar for both wild and captive females. It was also observed that the male shrimp touched the discarded female molt shell or stayed nearby for some time. In some of the recordings, it was seen that the male shrimp ate the female's molted shell or the male killed or ate the newly-molted female. Mating was not yet observed in any of the trials.

Histological and gonad morphology evaluation of the captive and wild male breeders was also done.

Video capture of tiger shrimp in a mating behavior experiment

It was noted that the gonad of a wild male is slightly opaque white in color compared to that of the captive male which is translucent in color.

Grouper

Giant groupers (*Epinephelus lanceolatus*) were observed to directly undergo male sexual maturity contrary to the general idea that groupers are protogynous hermaphrodites wherein all individuals mature first as female and then reverse to male. Furthermore, females were noted to mature at 22-25 kg body weight and 95-99 cm total length while males matured at 15-20 kg and 81-92 cm.

Spontaneous spawning of giant groupers in the floating sea cage was achieved through hormonal manipulation using slow-release gonadotropin-releasing hormone (GnRH) implant and human chorionic gonadotropin (hCG) injection but fertilization rates have been highly variable. Treatment with hCG (500 IU/kg BW) was not effective for induced spawning of giant groupers. Spermiation can be induced in males through treatment of hCG (1000 IU/kg BW) although better results were obtained when slow release GnRH pellet (60-80μg/kg BW) was implanted 48 hours prior to hCG treatment. For females, GnRH treatment alone effectively induced final oocyte maturation and ovulation. Hence, timing of GnRH and hCG treatment can be modified between the two sexes so that the final maturation of female and male gametes would occur at the same time, either for spontaneous spawning or stripping and artificial fertilization.

Appropriate larval food for giant grouper was sought. Inclusion of *Proales* during the first 10 days of rearing resulted in significantly higher larval survival rate. Recently, giant grouper larvae were reared in 3-ton circular tanks and *Proales*-supplement was given starting day 1 and *Brachionus* was fed on day 2 and onwards. Spines were observed at day 16, however, only the shooters metamorphosed to juvenile stage. Given *Proales*' benthic nature, the increased frequency of direct feeding and the utilization of

dripping method yielded successful rearing (day 35 survival rate: 0.3%) as compared to the trials previously done in giant groupers with no survival at day 35.

Cryopreservation of grouper sperm was investigated to prolong their viability through storage in liquid nitrogen or in a -80°C biofreezer. Sperm motility was better retained in cryopreserved tiger grouper sperm while long-term fertilization capacity was only confirmed in giant groupers. Generally, viability remains despite a total loss in sperm motility.

Initial results in evaluating suitability of Ficoll 70 as additive to the MPRS-DMSO (9:1 v/v) sperm extender at -80°C storage showed a dose-dependent effect in terms of preserving viability. However, addition of Ficoll 70 does not positively affect motility conservation, which only lasted up to one month of cryopreservation. Further trials tested the effects of the extender pH (5.0, 6.0, 7.0, 8.0) on sperm motility for sperms stored at 4°C. For giant groupers, highest motility was observed in the treatment with pH 7 followed by pH 6. A 15-day refrigerated storage was the maximum duration yielding observable motility.

Hybrid grouper show no sign of a developing gonad at 2 kg and 2.5 kg body weight

Ovaries of orange-spotted grouper, *Epinephelus coioides*. A smaller 0.6 kg-grouper had a bigger, more developed ovary (top) than a 1.0 kg-grouper (bottom).

Polychaetes

The critical stage during the early development of *Marphysa* sp. has been identified, hence, the rearing and feeding techniques for its mass production is being refined. In the nursery, a significant decrease in the survival of polychaetes after 45 days of rearing showed that the extension of rearing period on biofloc from a month to 45 days is not favorable. During this period, it is probable that they already need suitable substrate (mud) and food (formulated diet) for further development until the adult stage. This can be considered as their critical stage being their transition from early juvenile to juvenile stage.

Egg hatchability and larval development of *Marphysa* sp. subjected to varying irradiance and photoperiod treatments have been investigated. Results showed that the no light treatment had the highest survival.

The optimum stocking density and sediment depth requirement of the polychaetes during their nursery and grow-out phases was also determined. There was no significant difference on the survival of Marphysa sp. stocked at densities of 10,000/m^2, 20,000/m^2, 30,000/m^2 and 40,000/m^2. In terms of growth, a density of 10,000 trochophores/m^2 resulted in the highest number of segments.

Refining hatchery and nursery management protocols to improve seedstock production

Glass eels

A study to determine the feasibility of nursing Philippine native glass eels in captivity was started late 2017 and continued this year. Development of a suitable feeding scheme and formulated diets for glass eels and young elvers was done. Identification of anguillid eels based on morphological and genetic characterization was conducted. Potential pathogens in nursery eel systems were also identified.

DNA analysis being done at the Onagawa Field Science Center

Initial feeding trials of glass eel samples from Aparri, Cagayan Province were conducted for 24 weeks. Results revealed that a diet of *Tubifex* sp. resulted in the highest weight gain (3,679%) and survival (77%). Formulated and commercial diets gave poor results. Weaning trials were also conducted. Glass eels from General Santos City in Mindanao were fed *Tubifex* sp. alone until week 2, tuna eggs and *Tubifex* sp. from week 2 to 8, and formulated diets and *Tubifex* sp. from week 8 to 22. Formulated diets were moist, semi-moist and dry feeds. Results showed that semi-moist feeds resulted in the highest weight gain of 1,171%. Survival after 22 weeks of rearing was highest with moist feeds at 89% and lowest semi-moist feeds with only 84%.


Glass eels being acclimated to a holding tank

An experiment to determine weaning duration was also done. Growth in terms of final body weight, percent weight gain and specific growth rate was significantly higher in *Tubifex*-fed glass eels (control group) compared to those gradually weaned onto paste diet for 28 and 42 days. No significant difference was observed in survival rates of eel groups gradually weaned onto paste diet and that of the control group.

Meanwhile, glass eels pre-sorted/identified as *Anguilla bicolor pacifica* from Mindanao were stocked at 1.96 individuals per liter in nine 500-L polyethylene tanks with 250 L low saline water. Glass eels were fed *Tubifex* sp. four times

daily at 50% of estimated body weight. *Tubifex* sp. were placed in plastic baskets which served as feeding and resting stations for the eels. After two weeks, survival rates ranged from 93.3% to 99.8%.

The stocks used for the feeding trials which came from batches of glass eels collected in 2017 and 2018 were morphologically and genetically identified. The genetic characterization and identification of the 2018 samples (comprised of samples used in selected nursery farms and wild sourced eels) were completed at the Onagawa Field Science Center of the Tohoku University. Analysis on the DNA barcoding data using cytB is ongoing. Apart from mtDNA sequence analysis, seven microsatellite primers used in anguillid species were successfully tried on the Philippine anguillid eel samples and the protocols for cross-amplification and microsatellite analysis were optimized.

The glass eels and the rearing water from surveyed eel nursery farms were monitored for the presence of pathogens. Bacterial analyses of the water samples were conducted as well as parasite identification and load in the fish samples were also conducted. The bacteria from the fish samples were obtained from the kidneys. Among the parasites found in the eel samples are *Trichodina* and monogenetic trematodes. The highest prevalence of *Trichodina* was found in Zambales with 90% prevalence. It also had the highest intensity as well as mean abundance. In the case of monegeneans, the Zambales farm had the only incidence with 50% prevalence. For monogeneans, only the farm in Zambales showed the presence of this parasite.

Sandfish

Optimizing the hatchery production of early sandfish *Holothuria scabra* juveniles continued in 2018, primarily aiming to stabilize seedstock production with at least 5% survival and a production volume of 20,000 early juveniles per spawning batch. From January to November, a total of 21 spawning attempts were conducted. Target production was achieved by four batches, the highest being 86,536 in August. In terms of survival, larval rearing trails in April and August achieved more than 5% survival. However, three batches still produced less than 12,000 attributable to cold temperatures in January and February, low supply of larval food for some trials in April and May, and high precipitation and low salinity in July to September.

Also in 2018, production of sandfish juveniles in tank-based nurseries was explored. To optimize growth and survival of sandfish juveniles to 20 g fingerling size, rearing was divided into two nursery phases: primary nursery phase for early juveniles (<5 mm to >40 mm or 3 g) and secondary nursery phase for late juveniles (3 g to >20 g). A preliminary run of the primary nursery operation was done in tank-based floating hapas (1 x 2 x 1 m) from September to November yielding 49-55% survival and final weights of 1.48-1.51 g at 500/hapa initial stocking density.

The rearing performance of secondary nursery system for late juvenile sandfish (>40 mm) in tanks was also evaluated. A preliminary experiment focused on the adoption of supplemental feeding. Three feed types were used: milkfish larval feed (ML), shrimp starter feed (SS), and *Sargassum* powder (SP), and a control with no supplemental feed. Initial results for the first 30-d revealed that sandfish fed with

Sandfish, *Holothuria scabra*, early juveniles

ML had the highest growth rate at 0.09 g/d, followed by SS at 0.01 g/d. On the other hand, sandfish shrunk when fed with SP (-0.01 g/d). Sandfish dependent only on natural food with no supplemental feeding shrunk even more (-0.02 g/d).

Seaweed

Micropropagation of seaweed plantlets using vegetative thallus was done in the land-based and sea-based nursery to promote *Kappaphycus* culture. Seaweeds were grown in in vitro and net cages to provide continuous supply of cultivars for mariculture. The culture condition was optimized in the laboratory and in cages. Plantlets that were grown in vitro for 3 months, were successfully planted in nursery nets at the Igang Marine Station. Propagules were further reared in the sea-based nursery for two to three months until they are approximately 6 to 10 g. Plantlets were likewise successfully out planted in the Philippine provinces of Bohol, Iloilo, Guimaras, Samar, Davao, Basilan and Antique. The performance of propagules from the nursery is being assessed and the cost estimated for the production of plantlets in land and sea-based nursery.

In 2018, about 22 batches (from a total of 24 batches with two batches mortality) were harvested from the indoor laboratory where a total of 38,000 plantlets were produced in the land-based nursery with monthly average of approximately 3,000 plantelts with average length of 10 mm. In sea-based nursery cages, a total of 12,113 plantlets were produced.

Tetraselmis paste in bottles. *Tetraselmis* paste proved better than *Nanochlorum* paste as feed for rotifer culture.

Algal paste

A study was done to establish optimal conditions for the production of algal paste through electrolytic flocculation. This is through the manipulation of the design and operation of the flocculator by modifying factors such as current/power source, salinity, and the flocculator's metal component. The pastes produced were assessed in terms of viability, length of storage and metal residues that may be found in the paste.

Preliminary culture and scale up of algae was done for diatom *Chaetoceros calcitrans*. Results show the potential of *C. calcitrans* for mass production and subsequently for algal paste production as it can easily be mass-produced in four days. In scale up cultures to 10 L and 100 L, division rate (k) was calculated at 0.79 and 0.75 cells/day, respectively. Highest cell counts were 4.7 x 10^6 cells/mL for 10 L and 1.3 x 10^6 cells/mL for 100 L.

For flocculation, three units of variable power supply machine were fabricated. One voltage setting (12V) was used and the treatments varied from the number of aluminum tubes and lead sheets used, i.e. 2-2, 4-4 and 6-6, respectively. More paste was harvested from the 6-6 combination but no significant difference was noted between treatments.

For paste quality assessment, biochemical profile results for % lipid and % protein showed no significant differences between treatments. Chlorophyll content and % carbohydrates were higher in paste but were also not significantly different between treatments. Lead content in paste using 6 anode 6 cathode was lowest (83.7±0.3 mg /L) than that found in the other treatments of using 4/4 anode/ cathode and 2/2 anode/cathode. In terms of viable cells, there is no significant difference when using variable anode/cathode electrodes 6/6, 4/4, and 2/2.

The use of algal paste in rotifer cultures for mangrove crab *S. serrata* seed production was evaluated. Initially, *Nanochlorum* paste was used in rotifer culture but *Tetraselmis* paste proved to be a better option. Hence the protocol for the use of *Tetraselmis* paste was refined. It was shown that algal paste that was acclimated and activated for four hours prior to feeding to rotifers gave better results than feeding rotifers with Tetraselmis batch culture.

High density packing of milkfish juveniles inside a transport bag

Milkfish

The development of a protocol to transport milkfish juveniles from the nursery to sea cage facilities was continued. Results showed that milkfish juveniles (5-7 inches) can be transported for up to 12 hours in a closed system under various salinities and temperatures with minimal mortalities. The conditioning period of confinement prior to juvenile transport was shown to be best at 4 weeks and the least favorable was 1 day. As for the effect of 2 phenoxy-ethanol (PE) as sedative during juvenile transport, it was noted that survival was comparable in treatments that have 2 fish/L, 4 fish/L, 4 fish/L plus 50 ppm PE and that of 6 fish/L plus 50 ppm PE.

Increase awareness on available genetically selected and improved stocks and optimize their use for improved on-farm aquaculture production

This year, the genetic improvement research initiatives that have been completed for abalone and mangrove crab are as described in the section on broodstock development. The mangrove crab project is aiming to produce fast growing and disease resistant lines while the abalone project focused on improved breeding performance through strain comparison and evaluation and other beneficial traits such as growth. Once lines and strains have been identified and are confirmed to be better, both improved strains and the protocols that were formulated to produce these improved stocks are to be documented and the stocks, if any, can promoted for dissemination. This study is funded by Philippines' Department of Science and Technology (DOST).

Promotion of technically and economically viable breeding and seed production schemes

From February to October 2018, 13 spawning episodes were documented for abalone *H. asinina* in the AQD hatchery producing a total 22 larval batches. Spawning generally occurred 12-15 days after the last spawning episode.

Out of 420 conditioned females in the hatchery, an average of 12.8 broodstock spawn every spawning episode. This gave a spawning success rate of 3% using seaweed *Gracilariopsis heteroclada* as food. Larval production per spawning episode averaged 2,482,806 with an average survival rate (from trocophore to veliger stage) of 68%. Average fecundity is 155,561 eggs per female.

After four spawning episodes, the hatchery was able to produce around 198,896 early juveniles. Production yield and survival rate of juveniles from stocked veliger larvae is 3.11%. Improved post-larval nutrition is the main contributing factor to the increase in the yield of juveniles.

The seaweed *Gracilariopsis heteroclada* used as food for abalone

Mangrove crab broodstock (mature female crab) used to produce crab instars (with 0.6-0.8 cm carapace width) were obtained from grow-out farms in Dumangas Brackishwater Station and Capiz province. A total of 185 broodstock were collected and 70 of these crabs spawned. The recent collection of broodstock was 23 November 2018. From the recorded spawnings, only 36 produced viable larvae and the remaining spawners had unfertilized eggs. The current number of crab broodstock maintained in the hatchery is 53 pieces. A total of 615,235 crab instars were produced with buyers from Iloilo, Capiz, Aklan, Negros, Masbate, Pangasinan, Pagadian and Zamboanga provinces.

***Chaetomorpha* sp.**
This green macroalgae is being sun dried in preparation for its incorporation as a protein source in feed.

Healthy & 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.

Promotion of conventional and new diagnostic methods

Tilapia Lake Virus (TiLV), an RNA virus, is an emerging disease that has become a serious threat to the culture of tilapia in Asian countries. Detection, quantification and viability of TiLV in pond soil and water influenced by water quality parameters and culture development was conducted.

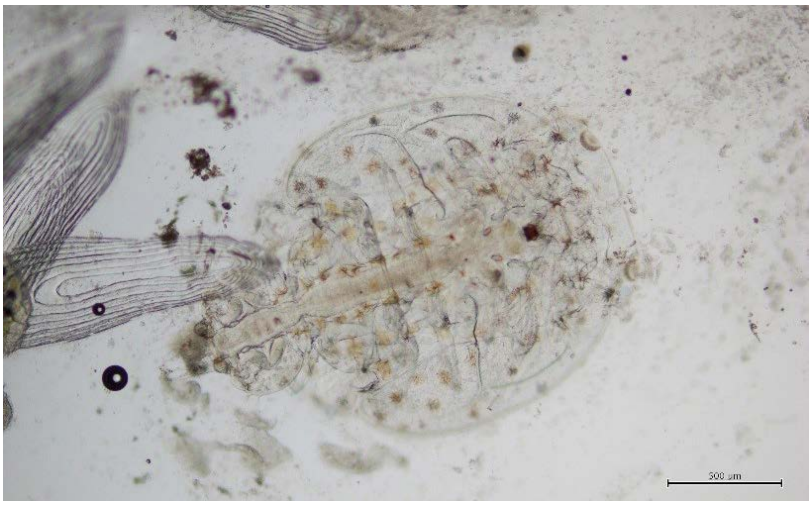
The study collected tilapia, soil, and water samples from the same culture facility. Semi-nested Reverse Transcription Polymerase Chain Reaction (Semi-nested RT-PCR) and Quantitative Reverse Transcription – PCR (qRT-PCR) were used to detect and quantify the virus. Tilapia samples (18 cultured, 5 wild) tested negative using one-step PCR while one sample was tested positive using nested PCR. Validation and optimization of protocols for TiLV detection in soil and water samples are ongoing.

Trial sampling for detection of diseases and pests in farmed and wild seaweeds was conducted. The objective of the study is to produce detection and molecular diagnostic tools to properly identify the pests and diseases in seaweeds. Seaweed samples were taken from Inampulugan Island in Guimaras and initial results showed that epiphytes were present in both wild and farmed seaweeds. Intensive samplings were then conducted in six sampling sites around Central and Southern Philippines. Epiphytes and ice-ice were observed in the collected samples. An initial batch of seaweed samples was processed for histology and a set of samples are currently undergoing electron microscopy analysis. The identified samples from trial and intensive samplings will be compiled in a central, open-access database and biobanks.

The effectiveness of current biosecurity practices and legislation on seaweed farming in the Philippines is being evaluated. Existing legislative policies on seaweed farming were compiled and analyzed for a systematic review. Farmers in Zamboanga in the Philippines were interviewed to determine the : (1) current management biosecurity practices and legislative structures for invasive pests and diseases; and (2) effectiveness of existing farm management and biosecurity practices. Farmers in three sites (Layag-layag, Tigtabon Island, and Talabaan) were interviewed. The results revealed that farmers don't want the government to take charge on the seaweed farming and think that the government causes more problems instead of actual solutions.

Finding effective and safe alternative drugs

A study to test the efficacy of different therapeutants against *Caligus* sp. (sea lice) in tropical fish under laboratory conditions has begun. The objectives of the study include the investigation of toxic effects of emamectin benzoate in pompano (*Trachinotus blochii*), determine the effective dose in laboratory assay by exposing pre-adult and adult sea lice collected from infested pompano; and evaluate the efficient oral administration of emamectin benzoate in the control of sea lice infestation in pompano. Rearing of pompanos to juvenile stage prior to testing is ongoing.



Sea lice, *Caligus* sp.

Regional Technical Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia

Fish health experts call for proactive approach to 6-billion dollar problem

Resource persons, country presenters, consultants and working staff present during the ASEAN Regional Technical Consultation

BANGKOK, Thailand – Representatives of ASEAN member states called for proactive approaches to address diseases in farmed aquatic animals that is costing the region almost six billion dollars annually.

"Disease is the number one issue in limiting yield, reducing profit and preventing investment," said Dr. Melba Reantaso, an aquaculture officer from Food and Agriculture Organization, during a recent consultative workshop held to examine the ASEAN region's readiness and response system for aquatic diseases.

Fish health experts and industry representatives from around Southeast Asia agreed that setting up biosecurity systems in farms and hatcheries are more cost-effective and better than having to find solutions once diseases hit.

"Emergency preparedness is the ability to respond effectively and in a timely fashion to disease emergencies and early warning is having advance knowledge of high risk diseases likely to threaten biosecurity," Dr. Reantaso added.

In the workshop, country representatives and members of the private sector identified workable ways to establish a functional and effective engagement on emergency preparedness and response system in each country.

"Aquatic animal disease outbreaks are likely to continue and there will be more new threats to come," said Dr. Eduardo Leaño, a coordinator from the Network of Aquaculture Centres in Asia-Pacific (NACA) who reviewed the history and impact of transboundary diseases on ASEAN aquaculture.

According to Dr. Reantaso, emergent diseases in aquaculture are mainly driven by trading of live animals and products, limited stakeholder knowledge on pathogens and their hosts, poor aquatic management and health control, and changes in the ecosystem.

Meanwhile, Dr. Leaño suggested to have a collaborative approach between research, government and the industry in coming up with a system on preventing and responding to aquatic diseases.

Lack of collaboration was the main gap identified during the workshop. Lack of funding and resources and poor information sharing and seeking efforts were other identified gaps.

The Consultation

The ASEAN Regional Technical Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia was held last 20-22 August 2018.

The Consultation discussed the status of and the need for aquatic emergency preparedness and response systems through country presentations, technical presentations and a workshop. Existing laws, legislations and standard operating procedures, among others, were reviewed. Gaps, policy recommendations and priority areas for R&D collaboration were discussed.

The consultation was organized by the Aquaculture Department of the Southeast Asian Fisheries Development Center together with NACA and Department of Fisheries-Thailand with funding support from the Japan-ASEAN Integration Fund.

Promoting practices or strategies to improve production

The production of *Penaeus vannamei* using biofloc system with sludge removal facility in old earthen brackishwater ponds during wet season as well as verifying the economic benefits of using the system, was demonstrated. Soil preparation was completed, biosecurity facilities e.g. bird-scare, crab fence were installed, and pond facilities e.g. feeding bridge, feeding boat, discharge pipe, depth gauge, secchi disks and others were fabricated. Experiment will commence once pond preparation is completed.

Postlarvae of *Penaeus indicus*

The hatchery production and semi-intensive pond culture of white shrimp *Penaeus indicus* are being improved for sustainable supply. For hatchery, broodstock were sourced from Tigbauan and Antique and were placed separately in tanks with 10 pairs of male and female. Problems on the availability of natural food and delayed molting during cold months limited the hatchery production which mostly led to mortality of larvae. Postlarvae produced were mainly used for the semi-intensive pond culture experiment.

For semi-intensive pond culture, a study compared shrimp growth by using formulated *P. indicus* feeds (34-40%) and low-cost tilapia feeds (28-35%). Six ponds (700 m^2/pond) in AQD's Dumangas Brackishwater Station were prepared (cracked dried and applied with lime) with inorganic fertilizers (46-0-0 and 16-20-0), tea seed powder and crustascide. Three ponds are for testing *P. indicus* feeds and the other three is for tilapia feeds. Each pond was stocked with 20 individuals/m^2.

Determining specific nutrients that enhance growth performance

Amino acid (leucine, isoleucine and histidine) requirement for Asian sea bass juveniles is being quantified. In lieu of sea bass due to unavailability during the testing period, grouper (*E. fuscoguttatus*) juveniles were given diets with different levels of leucine (0%, 0.25%, 0.5%, 0.75%, 1.0% and 1.25%). Each test diet has an amino acid mixture with aspartic acid (13.5%) and Peruvian fish meal with squid meal (60%). Following the 8-week trial, the leucine requirement for grouper is 2.89%. Proximate composition analysis, amino acid analysis, and protein retention together with more data analyses are still ongoing.

The potential of thraustochytrid as alternative lipid source for fish oil in hatchery-bred abalone (*Haliotis asinina*) was assessed. Abalone juveniles had been reared to broodstock sizes specifically for the experiment. Protocol for harvesting cultured thraustochytrid changed from 4 days to 3 days. Culture and harvesting of thraustochytrid is ongoing to meet the required amount of extracted thraustochytrid oil.

Finding alternative protein sources in dietary formulations

Protein is the most important component of aquaculture feed and the common source of protein is fish meal (FM). This commodity is currently expensive and its availability has been predicted to dwindle in the coming years. With this scenario, the program has been conducting researches that would decrease FM inclusion in formulations while finding new protein sources that will not affect feed efficiency.

One usable by-product is the milkfish offal processed into hydrolysate. Tilapia (*Orechromis niloticus*) larvae given a diet containing 15% milkfish hydrolysate has similar growth, survival and feed intake with those fed a formulation without milkfish hydrolysate. The protein-enhanced copra meal (PECM) was also evaluated as an ingredient in formulated feed for a grouper species, *Epinephelus fuscogutattus*. Performance parameters of grouper were the same at 0-16% dietary PECM and morphology of liver and digestive tract were not altered at all. In another study on *E. fuscogutattus* the amino acid leucine requirement for growth was found to be 2.89% of the diet.

Macroalgae are other potential inexpensive marine protein sources that could partially replace fishmeal in feed formulations for finfish and crustaceans. The green macroalgae *Chaetomorpha* sp. contains about 17% protein which can still be increased when processed. Solid-state fermentation protocols are being developed to improve both the nutritional value and digestibility of *Chaetomorpha* meal while feeding trials show shrimp and tilapia could tolerate certain levels of unfermented *Chaetomorpha* meals in their diets.

Harvesting *Chaetomorpha* sp. from a shrimp hatchery waste water catchment canal

Fresh *Chaetomorpha* sp.

Mangrove crab, *Scylla serrata*, was studied to promote synchronized molting. A formulated diet will be supplemented with phytoecdysteroids crude extract (PCE) from spinach to induce molting. The application of PCE in addition to dietary inclusion will also be administered by injection. The extraction of PCE from spinach has been improved but is still being refined.

Harvesting abalone from pipes at Sicogon Island, Iloilo Province.

Maintaining **Environmental Integrity**

Responsible aquaculture entails the development of environment-friendly technologies and the monitoring of its impacts on biodiversity and the quality of the water and sediments. Propagation of threatened species will also enable the restocking and replenishment of their natural population.

Development and promotion of efficient and suitable environment-friendly culture systems

Abalone

A three-year study on abalone (*Haliotis asinina*) is ongoing to verify a newly developed technology using pipes for grow-out culture in different areas of Panay Island. The first site is Sicogon, to be followed by Aklan in 2019 and Antique in 2020. The Sicogon project is a partnership between SEAFDEC/AQD and Ayala Corporation. A total of 2,475 abalone juveniles have been stocked in perforated PVC pipes in the project site. Growth of the stocks are being monitored monthly. Two months after, the abalone have grown to an average weight of 9.30 g and shell length of 3.49 cm which is much better than those obtained in a previous study, using similar pipes as a method of culture but located in a different area.

Abalone harvested after 4 1/2 months of culture.

SEAFDEC Team together with caretakers showing abalone harvested December 2018 from those stocked in July 2018

Giant freshwater prawn

Strategies to improve giant freshwater prawn through stock manipulation and management were explored. Advanced juveniles of *Macrobrachium rosenbergii* were stocked in in a floating net cage set-up at Binangonan Freshwater Station at a stocking density of 15 pieces/m2. Prawns with average weight of 2.6 g were stocked with the following treatments: all male (AM), all female (AF), and mixed sex (MS). Results after six months of cage culture showed that there was significant difference in the weight of prawns with those from AM having significantly higher average weights compared to both AF and MS. No significant difference in survival was noted among treatments. Fig. 1 shows the growth of the prawns in the different treatments while Table 2 summarizes the production parameters at the end of the six-month run. AM showed the best production parameters compared to the two treatments. The MS had the most pronounced heterogeneous individual growth (HIG) as indicated by the highest coefficient of variation in size. All male culture of giant freshwater prawn can be adopted to improve production.

Polychaetes

Due to some successful runs last year producing polychaetes (*Marphysa* sp.) using katsa (cheese cloth) cages installed in brackishwater ponds, two more experiments were conducted at DBS. The 1st experiment compared two culture beds: A- directly in soil surrounded by katsa cages without bottom and B- soil inside katsa cages supported by false bottom. Results showed that polychaete trocophores cultured for three months in B had higher body weight and survival (0.50 g and 0.9%,) than those reared in A (0.35 g and 0.4% respectively). The 2nd experiment with two runs compared four stocking densities. Results indicated that *Marphysa* sp. (3,000 trocophores/m^2) cultured in B for two months had higher survival (2.8% and 3.8%) at a stocking density of 500/m^2 while growth was better at - stocking density from 500/m^2 to 1,500/m^2. Cultured polychaetes were free of shrimp pathogens such as WSSV, AHPND, YHV and fish pathogen such as VNN. However, IHHNV was found in both polychaete samples and soil in the experiment site. Hence, new raceway ponds were constructed at a new site at TMS in order to fully implement biosecure systems while verifying the cage culture techniques developed to produce polychaetes.

At TMS, old and new adult stocks of polychaetes were screened for WSSV, TSV, YHV, IHHNV, VNN and Iridovirus and were found to be free from these pathogens Hence, these were restocked at a density of 500 individuals per tank for breeding.

Different diets were also tested for polychaetes. *Marphysa* sp. cocoons were collected from the broodstock tanks and trocophores were initially stocked in 4-L basins and grown

Production parameters for all male, all female and mixed sex culture of *Macrobrachium rosenbergii*. Figures are means.

Parameter	All Male	All Female	Mixed Sex
Final weight (g)	43.3	26.6	31.3
Size variation (%)	33.1	17.5	54.1 43 (male) 20 (female)
Survival (%)	57.5	66.3	57.2
DGR (g/day)	0.221	0.132	0.163
SGR	1.49	1.22	1.53
FCR	3.2	3.9	3.4

All male (top), all female (middle), and mixed-sex giant freshwater prawns (bottom) cultured in lake-based cages.

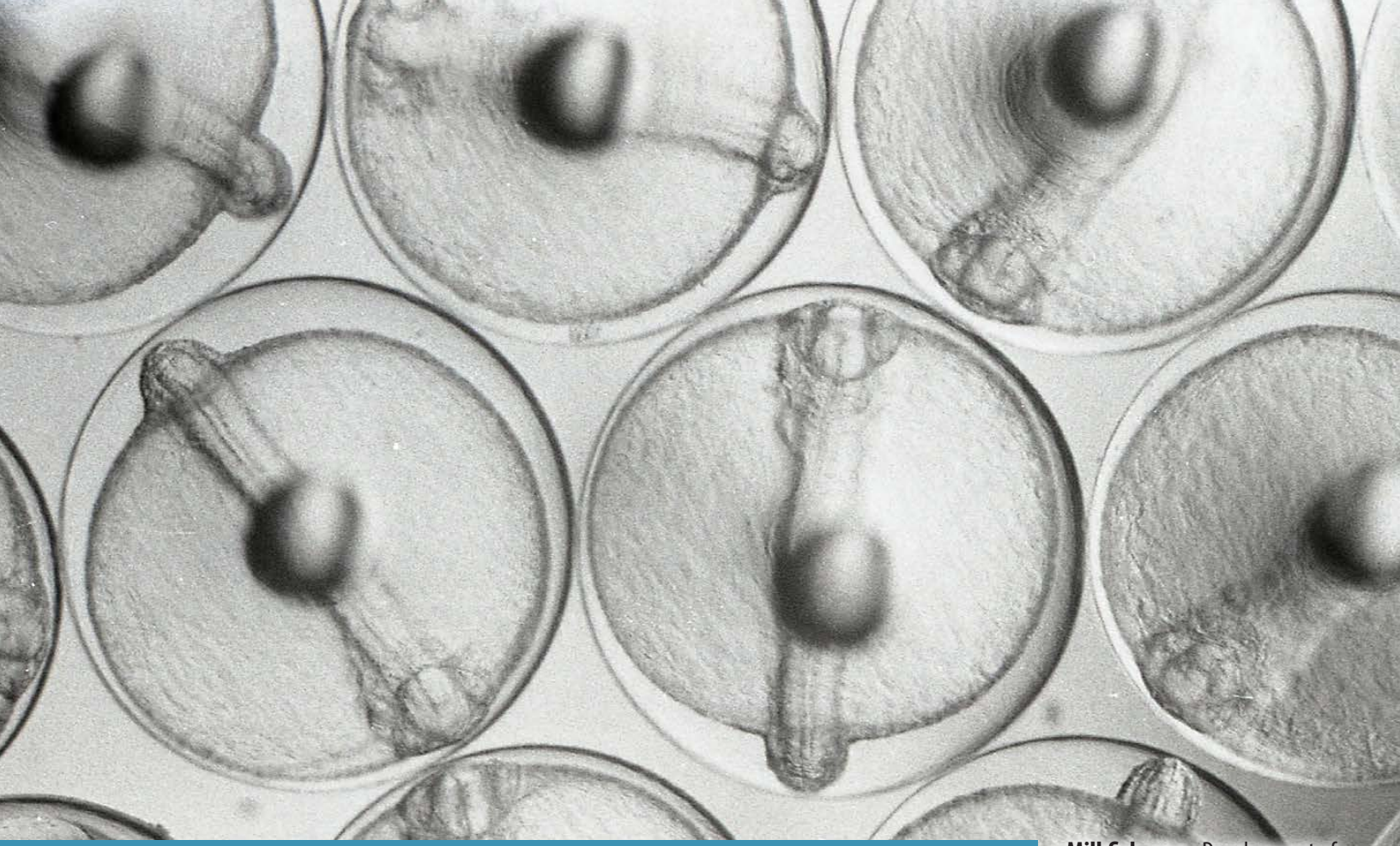
with biofloc for one month. In run 1, each basin contained 18,916 trochophores (37,831/m^2 stocking density) while in run 2, each basin contained 17,680 trochophores (35,360/m^2 stocking density). After 1 month, stock in each basin was transferred to a grow-out tank with soil sediment depth of 5 cm. Feeding at 10 g once a week using three diets (tilapia, milkfish broodstock, and high-value) was done. After 5 (run 1) and 6 (run 2) months, polychaete body weight, biomass, and survival were determined. A water flow-through system was followed throughout the culture period. On most days, salinity ranged from 20-30 ppt while during heavy rainfall, salinity dropped to 5-11 ppt. Sediment temperature was from 27-30 ºC.

Tank culture of *Marphysa* sp.

Marphysa sp. cage culture in brackishwater pond

Other activities

For the purpose of rehabilitating the prawn industry, SEAFDEC/AQD thru TVED (Technology Verification and Extension Division) launched "Oplan Balik Sugpo" that will be field-validated or demonstrated in strategic Bureau of Fisheries and Aquatic Resources (BFAR) pond demonstration sites nationwide. Information dissemination and extension to end-users nationwide will be further accelerated thru collaboration with BFAR and the private sector. The collaborative project between SEAFDEC/AQD and BFAR will be the Joint Mission for Accelerated Nationwide Technology Transfer Program (JMANTTP II).



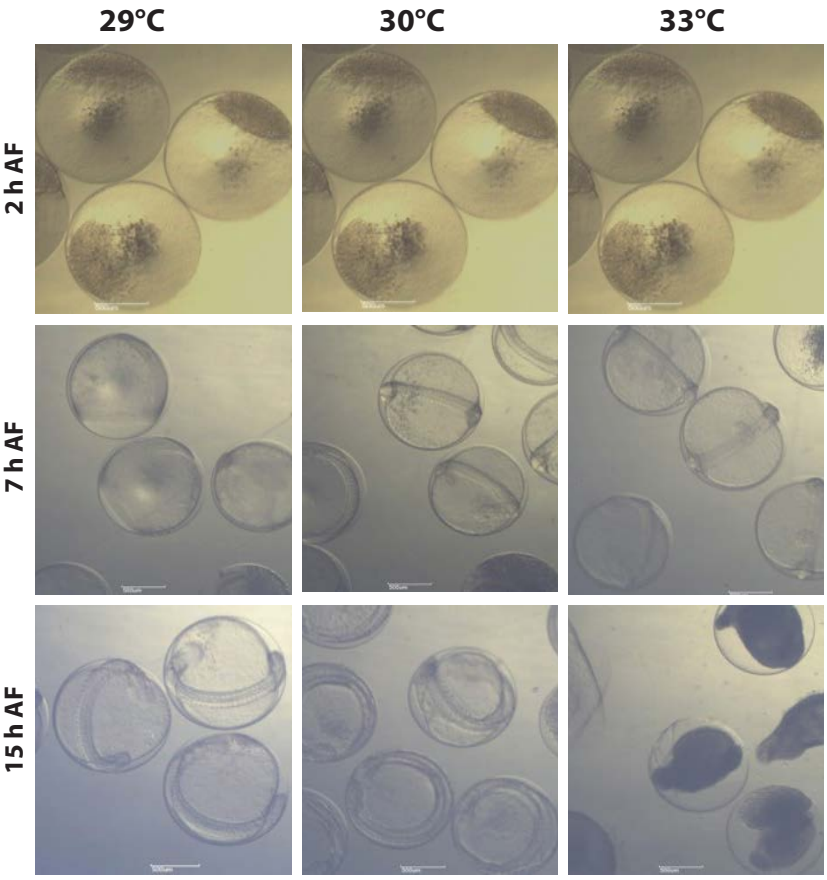
Milkfish eggs. Development of fish eggs can be disrupted or totally aborted if water temperature is elevated.

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.

The aquaculture industry must brace itself for inevitable changes in global climate patterns. Shifts in temperature are expected to have a cascading effect on weather, sea levels, ocean currents, sea surface temperatures, and the overall water chemistry. Little is still known on how these will impact the biology of cultured species as well as existing practices and infrastructure. To safeguard food security, an understanding of the present and potential impacts of climate change must be developed, especially for commercially important species.

Rabbitfish, *Siganus guttatus*, still displayed good gonadal development and spawning even at elevated temperatures of 31-33°C. Eggs of milkfish *Chanos chanos* and Asian sea bass *Lates calcarifer* and rabbitfish had lower hatching rate at 30°C and were aborted at 33°C. Larval survival was also affected by elevated temperatures with rabbitfish unable to survive at all at 33°C.



Egg development of milkfish at 2 hours, 7 hours, and 15 hours after fertilization (AF). Note the aborted eggs at 15 h AF in the 33°C treatment.

Mangrove crab, *Scylla serrata*, were also observed to fail to spawn during seasons of elevated temperature. Crab larvae at Z1 stage were more tolerant of elevated temperature (31°C) where Z1 stage had highest survival. However, Z2 to Z5 stages had lowest survival at 33°C. Overall, later stages of Z3 to Z4 were shown to be more sensitive to higher temperature.

Reproduction was disrupted and maturation rates decreased in abalone, *Haliotis asinina*. Female breeders died after 45 days at 33°C while only 10% of males survived until day 60. Gonad regression was also observed under the said conditions. Meanwhile, 50% of breeders survived at 30°C compared to the 80% survival at ambient temperature.

Increased amounts of carbon dioxide in the atmosphere is expected to lead to ocean acidification because of the absorption of the gas in seawater. With the average ocean pH now lower at 8.1, rotifers were shown to have lower population growth at pH 7.5. However, a higher temperature of 33°C at 20 ppt salinity resulted in significantly higher population growth (367-396 ind/mL at day 6). Meanwhile, the size of rotifers (87-200 um) did not appear to be affected.

On copepods, *Pseudodiaptomus annandalei* survival was lower in low pH of 7.5 and high salinity of 38ppt. *Acartia tsuensis* survival was low in low pH of 7.5 and low salinity of 20ppt.

The AQD Library continuously sends updates and new information on the effects of climate change to aquaculture to staff and stakeholders. Training courses offered at AQD incorporate climate change topics which were well received by trainees based on their post-training evaluation.

Monthly monitoring. Fisherfolk and researchers check the sandfish at the replicate site in Molocaboc Diut, Sagay Marine Reserve.

Meeting Social & Economic Challenges

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

Assessment of anguillid eel nursery industry

Due to the demand of eel seeds for aquaculture in recent years, a survey was done on the anguillid eel aquaculture industry with focus on glass eel nursery in the Philippines. This was part of the regional study "Enhancing Sustainable Utilization and Management Scheme of Tropical Anguillid Eel Resources in Southeast Asia" led by the SEAFDEC Secretariat and funded by the Japan-ASEAN Integration Fund (JAIF). The survey of eel nursery farms in the Philippines and Viet Nam, together with the observed practices in farms in Japan, aim to provide bases for studies on nursery refinements to improve current production.

Eel farms surveyed in the Philippines were in the provinces of Cagayan, Zambales, Laguna, Pampanga, Tarlac, Agusan del Norte, Saranggani, Cavite; and in Davao and General Santos City. In Viet Nam, farms in Khanh Hoa and Phu Yen in south central coast were surveyed. Most farms use indoor nursery facilities and outdoor ponds with static-renewal system of water exchange, recirculating system, or flow-through system with water sourced from deep wells.

In the Philippines, glass eels are sourced in Aparri in Cagayan province, and in Mindanao such as in General Santos City, Sarangani and Davao. In Viet Nam, eels are sourced from the provinces of Quang Ngãi (2-5%); Bình Đinh (10-15%); Phú Yên (>80%); Khánh Hòa (<1%); and Ninh Thuân (<1%). For both countries, post-transport survival is generally high at 95 to almost 100%. The price of glass eels in the Philippines range from P3,500 to P5,000 per kg, but pre-sorted glass eel with at least 90% *A. bicolor pacifica* are sold at P20,000 per kg. In Viet Nam where more than 90% of anguillid eels are claimed to be *A. marmorata*, the equivalent price range of glass eels is about P23,000 to P34,000 per kg.

In terms of good aquaculture practices, quarantine upon arrival (mostly through salt bath and rarely with antibiotics) are practiced in the Philippines but those in Viet Nam are stocked directly in rearing tanks.

Eel farmers report almost 100% survival after transport from source to nursery

Glass eels are mostly reared in indoor cement tanks with aeration and good water exchange

Economic benefits and losses of seaweed farmers

Seaweed is one of the major export commodities of the Philippines and its farming is often the livelihood of low-income households in many coastal communities around the country. However, seaweed production in the Philippines shows a declining trend while global demand for seaweeds and its products is projected to increase annually. Studies have also shown that coastal marine ecosystems along with the goods and services they provide are threatened by anthropogenic global climate change.

Seaweed samples collected after 30-days culture in shallow areas in Panobolon, Nueva Valencia (Feb to March 2018)

To better understand these climate-related concerns, key activities in 2018 included the monitoring of seaweed farming operations of fisherfolks in Panobolon, Nueva Valencia in Guimaras province. Likewise, test planting of seaweeds from AQD were implemented to provide comparison with seaweed farming livelihood in the study area.

Test planted seaweeds grew but were heavily infested with epiphytes, herbivorous fish and shells. The seaweeds were cleaned and replanted, but they grew in clumped form rather than showing long-branches. Majority of seaweed growers in shallow areas stopped cultivating in 2018 primarily due to unpredictable weather patterns and lack of seedling propagules. Farmers in shallow areas reported more problems such as profuse bloom of algae and the presence of mud, slimy worms, and black egg-like slime attached to the seaweed thalli.

Eventually the seaweeds melted due to "ice-ice" despite regular cleaning. The farmers who planted in deep areas continued farming, although confronted with the same challenges experienced by growers in shallow areas. Transition of season affected seaweed growth performance. Growers reported that extreme temperature and salinity resulted in depigmented seedlings and mortality. Despite the constraints encountered, a few growers continued farming until the early quarter of 2018. Overall, the seaweed growers showed a declining interest from 2016 to 2018 due to lack of good-quality seedlings and low market price of fresh harvest.

Community-managed milkfish IMTA and value-adding

SEAFDEC/AQD and the Japan International Research Center for Agricultural Sciences (JIRCAS) collaboratively implemented research studies on "Demonstration and Verification of Sustainable and Efficient Aquaculture Techniques by Combination of Multiple Organisms from 2016-2020". This project aims to establish practically feasible and economically profitable modified integrated multi-trophic aquaculture (IMTA) systems that suit local fish farming environment.

For the socioeconomics component of this project, milkfish, *Chanos chanos,* grow-out trials that explore and demonstrate improvement of IMTA systems were conducted with organized fisherfolks and the local government officers in Barangay Pandaraonan, Nueva Valencia in Guimaras province. As in previous years, this study incorporates science-based milkfish culture technology at SEAFDEC/AQD with the indigenous knowledge of fisherfolks. The key activities in 2018 include the sixth culture run that

once again demonstrated grow-out of milkfish with sandfish, *Holothuria scabra*. The milkfish harvest attained local marketable size (>250 g), but there is variability in the size distribution of harvest. Value-adding was done by deboning, cooking of under-sized milkfish in oil and the indigenous process of partial sun-drying of split-gutted milkfish washed in brine solution. The latter was preferred by local women because of lower cost. However, the techniques for integrating sandfish and seaweed culture in IMTA of milkfish needs further improvement. In 2019, a modified mariculture pen set-up will be stocked with more sandfish during the fallow period to verify improved survival and growth observed in 2018.

Integrated abalone and sandfish production through resource enhancement

Community-Based Resource Enhancement (CBRE) of abalone and sandfish has been conducted in an island community of coastal fishers in Barangay Molocaboc, Sagay Marine Reserve, Negros Occidental, Philippines. The project has been co-funded by SEAFDEC/AQD and GOJ-TF.

Stronger stakeholder collaboration has been achieved as well as improved fisheries management, and fisherfolk compliance to a locally initiated abalone 6-cm catch size regulation. Recovery of abalone and sandfish stocks were also sustained inside and outside of the protected release site in Molocaboc Dacu, initiated in 2011, and a replicate site in Molocaboc Diut, initiated in 2017. However, sandfish monitoring shows very few attain recommended catch size >320 g. Hence, information on sea cucumber harvesting guide, following national regulations, was disseminated to sustain successful sandfish releases and ranching outcomes in both islands.

Information materials distributed to guide sandfish gatherers on legal catch size based on Philippine national fisheries regulation

Additional activities include the constructions of a small-scale solar-powered abalone hatchery on stilts in between Dacu and Diut islands to train fisherfolks on the hatchery-based production of juveniles for stock enhancement. Also, freeze-drying and water activity test showed that abalone harvest subjected to 24-hour freeze drying reduced 90% moisture content and attain extended shelf-life without microbial proliferation and improve its market reach.

The project also looks into its replicability as AQD and Partido State University in Camarines Sur pursue collaborative social and fisheries assessment activities as prelude to a replicate in Lahuy Islands in Caramoan in Bicol Region.

Sandfish stock monitoring. Trained local fishers assist in monitoring sandfish stocks at the replicate site in Molocaboc Diut.

Sustainable Aquaculture & 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 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.

Fish Health Management

This program generally aims to develop and accelerate rapid and effective fish and shrimp health management; enhance the efficacy of vaccines against viral diseases in cultured fish and shrimp species; establish protective measures against persistent and emerging parasitic diseases; identify risk factors and develop protective measures against Early Mortality Syndrome (EMS); and extend and demonstrate technologies to practitioners and officers of member countries.

Develop rapid and effective diagnostics for shrimp health management

The continued occurrences of white spot disease and acute hepatopancreatic necrosis disease respectively caused by white spot syndrome virus (WSSV) and *V. parahaemolyticus* (VP_{AHPND}), among others, necessitate the establishment of domesticated shrimp stocks that are free from these pathogens. Early detection allows the implementation of immediate and appropriate interventions to control the spread of infection, thereby minimizing losses.

Activities this year led to the establishment of the standard curve using WSSV plasmid. The load of the viral stock was determined to be 1.6 $x10^7$ copies/g. The viral load from natural infection was also measured and resulted to one-step positive tissues ranging from $3.2x10^9$ to $5.1x10^{10}$ copies/g while the range for the nested positive tissues were from $7.4x10^5$ to $1.2x10^5$ copies/g. In the artificial infection (time-course experiment), the one-step positive tissues ranged from 1.2 to 5.1 X 10^9 copies/g while the range for nested was from 3.3 to 9.3 X 10^6 copies/g.

The threshold level of shrimp against WSSV infection was determined to be between 10^5 to 10^7 copies/g wherein mortality was not yet observed. The results also showed that threshold level of shrimp for WSSV infection was not weight dependent. It should be also noted that clinical signs of WSSV such as white spots were not observed in shrimps artificially infected with WSSV. The q-PCR protocol that was previously optimized proved to be sensitive and specific, hence, could be used for diagnostic purposes.

Enhancing vaccine efficacy for the prevention of viral diseases

Studies delving on enhancing the efficacy of vaccines against viral nervous necrosis (VNN) and white spot disease in fish and shrimp, respectively, were conducted.

To elucidate the field efficacy of the formalin-inactivated nervous necrosis virus (NNV) vaccine, grouper, *Epinephelus coioides*, juveniles were intraperitoneally injected with 100 μl of inactivated nervous necrosis (NNV) vaccine. Vaccinated fish exhibited neutralizing antibody titers from Day 30 (mean titer 1:1,792) to Day 150 (1:704) with the highest titer observed at Day 60 (1:6,656) post-vaccination. Since there is no mortality encountered in both vaccinated and unvaccinated fish during the course of the pond experiment, Day 30 post-vaccinated and L15-injected(control) fish were intramuscularly challenged with NNV. Nil and 25% mortality were respectively obtained in both vaccinated and unvaccinated fish. NNV titers in the brains and kidneys of dead unvaccinated fish ranged from $10^{10.9}$~$10^{11.4}$ $TCID_{50}$/g and 10^8~$10^{8.9}$ $TCID_{50}$/g, respectively. On the contrary, NNV was not detected in the brains and kidneys of any vaccinated fish examined. Additionally, NNV-challenge of Day 120 vaccinated and L15-injected/control fish resulted in nil mortality, suggesting an age or weight dependent susceptibility to NNV.

To develop a vaccination scheme using a combination of two antiviral treatments (rVP28 vaccination and rVP28 RNAi treatment) and develop a low-cost delivery protocol for antiviral treatments in tanks, a low-cost, bacterially-expressed production method was used to produce dsRNA. The efficacy of dsRNA was tested in several challenge experiments using various doses, different frequency of administration, and inclusion of heterologous dsRNA to test the specificity of gene silencing. The best treatment was determined to be a dose of 20 μg/shrimp administered four times over 28 days (two times before and two times after challenge (total = 80 μg/shrimp). It was also found out that the silencing was found to be specific to VP28 dsRNA. Production of rVP28 and dsRNA and determination of their encapsulation efficiency and yield in chitosan and alginate microparticles were conducted. Oral delivery using different ratios of dsRNA to rVP28 entrapped in microparticle carriers were also tested by challenge experiments in tanks.

Efficiency of greenwater system against AHPND in shrimp

To test the efficiency of greenwater system (using siganid, *Siganus guttatus*) against acute hepatopancreatic necrosis disease (AHPND) in shrimp, a simulated tank experiment employing infected shrimp cultured in siganid water (SGW) and non-SGW simulated environment using fiberglass tank with soil, was conducted. Shrimp survival was higher in SGW (46%) compared to non-SGW (24%). Bigger shrimp were harvested in SGW (ABW=3.9 g) than in non-SGW (ABW= 1.73). Shrimps exposed to SGW harbored less *Vibrio parahaemolyticus* in their hepatopancreas (1.2 x 104 cfu/g) compared to shrimps reared in non-SGW (4.95 x 105 cfu/g), suggesting that siganid greenwater could confer protection against *V. parahaemolyticus* implicated in AHPND.

Efficacy of garlic extract against persistent and emerging parasitic diseases in fish

The efficacy of garlic (*Allium sativum*) extract (powder form) against *Trichodina* sp. and sea lice (*Caligus* sp.) in Nile tilapia (*Oreochromis niloticus*) and pompano (*Trachinotus blochii*), respectively was examined via oral administration. Oral treatments using allicin powder-supplemented diet (1.25, 2.5, 3.75 and 5g/kg) and a control diet (without allicin) were tested in tilapia infected with Trichodina sp. for 14 days. Tilapia fed with allicin powder-supplemented diets have lower prevalence and intensity of *Trichodina* sp. compared with the control. A preliminary static bioassay aimed at determining the 96-h LC_{50} value of garlic extract in pompano juveniles was also carried out. Results of the experiment revealed that the 96-h median lethal concentration (LC_{50}) of allicin powder to pompano at 24, 48, 72 and 96 h of exposure were 29.18, 23.31, 16.79 and 6.64 mg/L, respectively.

Sustainable Aquaculture Project

This project aims to establish environment-friendly, responsible aquaculture technologies; promote community-based production and resource enhancement of high-value aquatic resources; and extend and demonstrate aquaculture technologies to member countries.

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

A study on using plant-based protein sources in tilapia feeds for improved production traits was conducted. It aims to produce tilapia with improved production traits using agricultural wastes and by-products as feed ingredients. In 2018, feeding trials were conducted to evaluate the suitability of fermented agricultural wastes and by-products (ABPs) in diets for tilapia fingerlings.

Set-up for the tilapia feeding experiment

Dietary inclusion of okara meal fermented with *Trichoderma harzianum* up to 15% had no adverse effects on growth and feed efficiency and was effective at maintaining acceptable sensory attributes such as texture and flavor on fish flesh. Growth trials are on-going to examine the effect of okara meal fermented with *Bacillus subtilis* in tilapia diet.

Database of Feed Ingredients now online

Students, researchers, aquaculturists and feed manufacturers will now have access to a comprehensive online database gathering more than three decades worth of research on fish feed ingredients available in Southeast Asia.

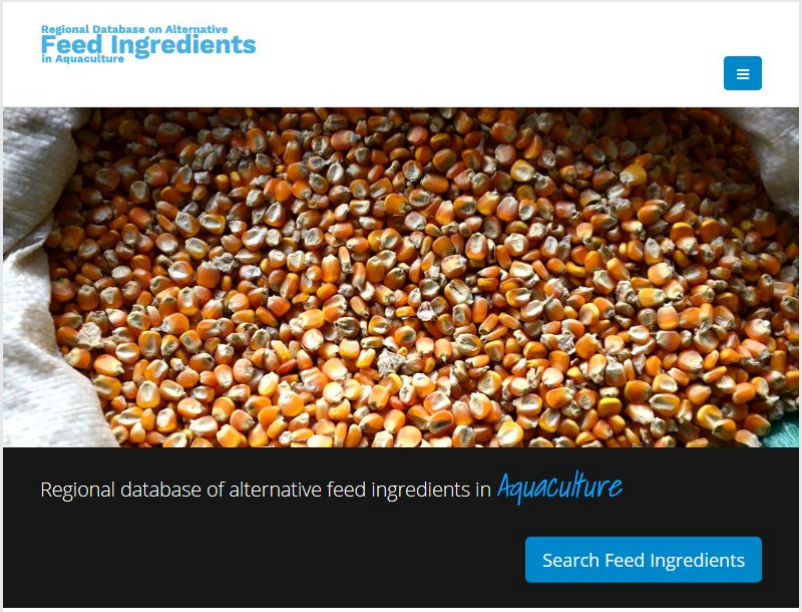
The Regional Database of Alternative Feed Ingredients in Aquaculture has been launched for public access as part of SEAFDEC/AQD's thrust to bring down the cost of feeds in aquaculture.

With feeds being the largest single cost item in aquaculture accounting for 50-60% of production cost, the database is intended to serve as a reference on the different feed ingredients that, depending on cost and availability, may be used to produce cheaper feed.

"Applying local ingredient alternatives for the formulation of an aquaculture feed is a way forward for the industry to remain profitable," said Dr. Roger Edward Mamauag, a scientist at SEAFDEC/AQD and head of the Nutrition and Feed Development Section.

The database currently lists 70 different feed ingredients along with their nutritional composition and optimal inclusion levels. The data have been culled from different scientific papers on fish nutrient substitutes which were found effective for commercial applications.

More alternative feed ingredients will soon be added to the database as representatives from SEAFDEC member countries have also been tasked to contribute information regarding their respective local ingredients, revealed Joseph Biñas, associate researcher and part of the team behind the database.



The home page of the Regional Database on Alternative Feed Ingredients in Aquaculture which is accessible at http://afid.seafdec.org.ph

Biñas added that, in the future, the public will also be invited to submit their inputs to further expand the breadth of the database.

"I think this is a very important initiative. We can mobilize other professionals in the feed industry, and from the regional laboratories, we can get as much as information as we can," said Dr. Yuan Derum, coordinator of the Education and Training Programme of the Network of Aquaculture Centers in Asia-Pacific.

"And we put all the information together, make it available for people who are interested and who will really use it to formulate economic feed for small-scale farmers," he added.

The need for a comprehensive database of ingredients was first proposed during the Regional Technical Consultation on the Development and Use of Alterative Dietary Ingredients or Fish Meal Substitutes in Aquaculture Feed Formulation held in Nay Pyi Taw, Myanmar on 9-11 December 2014 in an effort to widely disseminate information on alternative feed ingredients generated from numerous researches conducted in the region.

The database is a collaborative effort between SEAFDEC/AQD and SEAFDEC member countries through their representatives with funding support from the Government of Japan-Trust Fund.

The database was launched during the Book Launching ceremonies as part of SEAFDEC/AQD's 45th anniversary celebration on 12 July 2018.

The database may be accessed at afid.seafdec.org.ph.

Responsible aquaculture through aquasilviculture

Experiments were done to determine the time required for mangroves to remove nutrients (e.g. nitrogen and phosphorus) from shrimp farm effluents. During the experiments, the time required to remove nutrients from vegetated and non-vegetated environments were determined. Results showed that at a mangrove to pond ratio(MPR) of 4, ammonia was removed from the water after 3 days; TSS, two days; phosphate and chlorophyll, seven days. At MPR=2, only ammonia can be efficiently removed and after three days. Levels in MPR=0 remained high until after 14 days. Mangroves purify the water by nutrient uptake as indicated by the greater increase in stem length in saplings and trees in the area receiving shrimp farm effluents compared to the area with no effluent intake.

Bacterial treatment of selected agricultural wastes and by-products with *Bacillus subtilis* is explored to improve their nutritional composition

Community-based integrated production of abalone and sea cucumber

The first stock enhancement activity in Molocaboc Dacu in the multi-use buffer zone of the Sagay Marine Reserve continue to show increasing catch of abalone, *Haliotis asinina*, and sandfish, *Holuthuria scabra*, resulting from improved fisheries governance and management strategies for enhanced stocks in healthy habitat. From a baseline catch of 0-2 abalone individuals in 1-hour fishing effort by 3 divers (CPUE) before the first release of 2.4 cm shell length tagged hatchery-reared juveniles in June 2011, monthly monitoring of CPUE from July 2011 to December 2018 showed increasing proportion of wild individuals and sustained CPUE of up to more than 150 untagged individuals. For sandfish, advanced nursery in pens and grow-out in near-shore sea ranch area continue from 2015 to 2018 and produced harvestable 320 g size noted as early as Feb 2017. The density in the sea ranch continued to improve (12-17 individuals/ha in 2016; 53-128 ind/ha in 2017; 98-166 ind/ha in 2018) compared with the baseline (<3 individuals/ha in 2015).

Abalone hatchery on stilts in nearshore buffer area at Sagay Marine Reserve due to lack of access to land, similar to the social constraints of marginalized fisherfolks

Thus, releases and monthly monitoring of abalone and sandfish stocks continue to be conducted in a replicate site in nearby Diut island

with new fisherfolk participants. Other milestones achieved through successful collaboration include the construction of a solar-powered abalone hatchery. But the hatchery on stilts needs structural reinforcement to support more load.

Resource enhancement of seahorses

This activity aims to determine the appropriate time of release, determine growth and survival of the released seahorses, promote involvement of the community in the management of the natural resources, and to establish a community-based hatchery for seahorse. Due to the uncertain availability of juvenile seahorses from the hatchery, trials were conducted on the establishment of seed production techniques of seahorses in Molocaboc Island using available food from the sampling site.

Challenges were encountered but mitigated by installation of solar power system and training of fishermen organization members on the rearing of newborn seahorses. Currently, juvenile seahorses are being reared in submerged cages until they reach the ideal size of 7 cm stretched height for elastomer tagging. Trials on the acclimation of juvenile seahorses were done in hanging net cages prior to release in the pilot site. Also, information education communication activities will be conducted to promote resource conservation and protection of seahorses by giving lectures to school children and giving out posters to the local community and conducting interviews.

Three-month old seahorse juveniles

Submerged seahorse nursery cage

Capacity building programs

Two training programs, Marine Fish Hatchery Training Program and Rural Aquaculture Program were carried out under JTF6. The Marine Fish Hatchery Training Program conducted this year had 16 participants, four of which are supported by the Government of Japan. Topics included the breeding, hatchery seed production, nutrition and health management of grouper, seabass, and snapper. The Rural Aquaculture Program is a 10-day training focused on the promotion of community-based freshwater aquaculture for remote rural areas of Southeast Asia. This was conducted during the end of the year at AQD's Binangonan Freshwater Station.

Manpower Development. Selected fisheries graduates underwent intensive aquaculture training for eventual deployment to different culture facilities.

Training Program

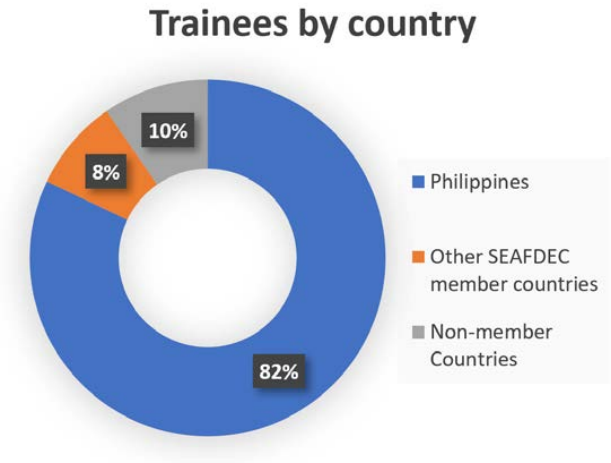
SEAFDEC/AQD continues to organize training courses and internship opportunities for the public to promote sustainable aquaculture technologies and help build the skills and capacities of fishfarmers, government personnel, the academe and other stakeholders.

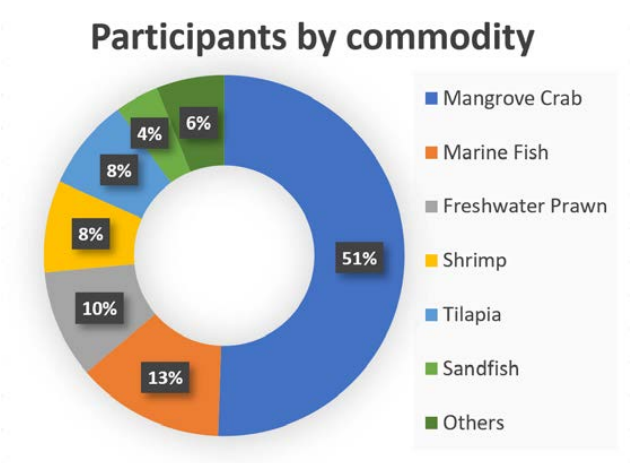
Overview

A total of 312 trainees participated in the 33 training courses organized this year with 27 nationalities represented. Profile of trainees revealed that 59% were private individuals, 4% identified with the academe and 37% were government personnel. Participants from the Philippines continued to dominate the trainee population this year (82%) in large part due to participants from the Philippine Bureau of Fisheries and Aquatic Resources.

Mangrove crab technology drew the most interest among the commodities with 51% of commodity-based training participants, or 141 individuals, interested on various phases of mangrove crab culture. A far second and third are trainees on technolgies for marine fish (13%), giant freshwater prawn (8%), shrimp (8%), and tilapia (8%). Majority of the trainees come from the private sector (59%), 37% come from the government.

Meanwhile, participation in the On-the-job-training Program surged to 435 students coming from 45 schools. This program allows the students, mostly BS Fisheries (136) and senior high school (107), to complete their respective school requirements. Also, a total of 25 individuals signed up for the Internship Program to gain experience at the various AQD facilities. Majority of interns (13) requested to be assigned at the marine fish hatchery.





Demonstration of line-point intercept transect method for substrate assessment during a practical session

Trainees learn different techniques of feed preparation at the SEAFDEC/AQD Feed Mill

Regular Training Course

Course, date, venue	Total participants	Countries represented by participants
Freshwater Prawn Hatchery & Grow-out Operations 5-9 February (BFS, Binangonan, Rizal)	11	Philippines
Distance Learning Course on Principles of Aquaculture Nutrition (AquaNutrition Online) 5 March - 3 June	10	Myanmar: 1 Philippines: 7 Singapore: 1 Spain: 1
Sandfish (*Holothuria scabra*) Seed Production, Nursery & Management 5-20 April (TMS, Tigbauan, Iloilo)	5	India: 1 Philippines: 2 Sri Lanka: 1 Thailand: 1
Freshwater Prawn Hatchery & Grow-out Operations 25-27 April (BFS, Binangonan, Rizal)	5	Philippines
Abalone Hatchery & Grow-out 9-25 May (TMS, Tigbauan, Iloilo)	3	Malaysia: 3
Marine Fish Hatchery 19 June - 25 July (TMS, Tigbauan, Iloilo)	16	Indonesia: 1 Maldives: 9 Myanmar: 1 Philippines: 3 Tanzania: 2
Tilapia Hatchery & Grow-out Operations 13-17 August (BFS, Binangonan, Rizal)	4	Philippines
Mangrove Crab Hatchery & Nursery Operations 13 August - 3 September (TMS, Tigbauan, Iloilo)	15	Indonesia: 1 Philippines: 10 Singapore: 3 Thailand: 1
Freshwater Prawn Hatchery & Grow-out Operations 11 - 15 September (BFS, Binangonan, Rizal)	11	Philippines
Mangrove Crab Nursery & Grow-out Operations 18 - 27 September (TMS, Tigbauan, Iloilo)	18	Philippines: 14 Singapore: 4
Community-Based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia 20 November - 4 December (BFS, Binangonan, Rizal)	5	Indonesia: 1 Myanmar: 1 Philippines: 3

Specialized Training Courses

Course, date, venue	Total participants	Countries represented by participants
Detection of WSSV Using PCR 1 - 3 March (TMS, Tigbauan, Iloilo) *Funded by Aqua Cards, Inc.*	2	Philippines
Manpower Development for Shrimp, Marine Fish & Tilapia Aquaculture 5 March - 7 May (TMS, Tigbauan, Iloilo) *Funded by SEAFDEC/AQD*	19	Philippines
Resource Enhancement 16-21 April (TMS, Tigbauan, Iloilo) *Funded by Government of Japan*	10	Cambodia: 1 Indonesia: 1 Lao PDR: 1 Malaysia: 1 Philippines: 4 Thailand: 1 Viet Nam: 1
Mangrove Crab Hatchery, Nursery & Grow-out Operations 22-24 May (Kalibo, Aklan) *Funded by Korea International Cooperation Agency*	31	Philippines
Distance Learning Course on Principles of Aquaculture Nutrition (AquaNutrition Online) Session 2 2 July - 30 September *Funded by BFAR / SANTEH*	13	Philippines
Mangrove Crab Aquaculture Technologies (Session 1 - Municipalities of Bagamanoc & Panganiban) 23-24 July (Viga, Catanduanes) *Funded by BFAR Central Office*	29	Philippines
Mangrove Crab Aquaculture Technologies (Session 2 - Municipality of Viga) 25-26 July (Viga, Catanduanes) *Funded by BFAR Central Office*	34	Philippines
Distance Learning Course on Principles of Aquaculture Nutrition (AquaNutrition Online) Session 3 6 August - 4 November *Funded by BFAR / CAMDEN*	16	Philippines
Marine Fish Hatchery (Sea Bass & Pompano) 6 August - 7 September (TMS, Tigbauan, Iloilo) *Privately funded*	1	Philippines
Natural Food Culture 13 August - 14 September (TMS, Tigbauan, Iloilo) *Funded by Mega Sardines*	2	Philippines
Mangrove Crab Fattening 4 - 6 September (TMS, Tigbauan, Iloilo) *Privately funded*	3	Philippines

Course, date, venue	Total participants	Countries represented by participants
Fish Health Management 24 - 28 September (TMS, Tigbauan, Iloilo) *Funded by Government of Japan*	6	Philippines
Sandfish (*Holothuria scabra*) Seed Production, Nursery & Management (Session 2) 4 - 19 October (TMS, Tigbauan, Iloilo) *Privately funded*	3	Saudi Arabia: 1 Singapore: 2
Inland Freshwater Aquaculture 8 - 24 October (BFS, Binangonan, Rizal; TMS, Tigbauan, Iloilo) *Funded by JICA*	8	Benin: 1 Cambodia: 1 Cameroon: 1 Fiji: 1 Kenya: 1 Myanmar: 1 Nigeria: 1 Zambia: 1
Marine Fish Hatchery 8 - 19 October (TMS, Tigbauan, Iloilo) *Privately funded*	1	Cameroon
Mangrove Crab Hatchery & Nursery Operations 8 - 26 October (TMS, Tigbauan, Iloilo) *Funded by Kalibo Save the Mangroves Association*	5	Philippines
Crab Fattening (Session 2) 15 - 17 October (TMS, Tigbauan, Iloilo) *Privately funded*	4	Bahrain: 1 Philippines: 3
Fish Health Management 22 - 29 October (TMS, Tigbauan, Iloilo) *Funded by Alson's*	6	Philippines
Mangrove Crab & Shrimp Hatchery Operations 23-29 October (TMS, Tigbauan, Iloilo) *Funded by Agriculture, Fisheries and Conservation Department (Hong Kong)*	2	China (Hong Kong)
Project Cycle Management 23-24 October (TMS, Tigbauan, Iloilo) *Funded by SEAFDEC/AQD*	18	Philippines
Algal Culture 12-23 November (TMS, Tigbauan, Iloilo) *Funded by RDEX*	2	Philippines
Micropropagation & Nursery Operations of *Kappaphycus* 26 November - 5 December (TMS, Tigbauan, Iloilo) *Funded by BFAR*	9	Philippines
Algal Culture 4 - 6 December (TMS, Tigbauan, Iloilo) *Funded by SEAFDEC/IFRDMD*	1	Indonesia

Internship and On-the-job-training

Course, date, venue	Total participants	Countries represented by participants
Internship at AQD hatcheries, laboratories and stations	25	Philippines
On-the-job-trainings a requirement in academic institutions	435 (45 schools)	Philippines: 431 Belgium: 3 Thailand: 1

Mangrove crab hatchery trainees prepare solutions for natural food production

A trainee on inland freshwater aquaculture injects bighead carp with hormone to induce spawning

Group discussions during the Project Cycle Management Training for SEAFDEC/AQD heads of offices

Training on *Kappaphycus* micropropagation at the laboratory

"Through micropropagation, we can come up with a solution regarding the decline of the stocks. From this technology that the SEAFDEC introduced to us, we can assure that we can deliver well-nourished and new plantlets for a new generation of the seaweeds industry of the Philippine

Muhaimin Maharail
Regional Seaweeds Coordinator
BFAR Region 9 (Philippines)
Training on Micropropagation & Nursery Operations of Kappaphycus

"Some of the other training that we have been to, in other institutions, or in other countries, the trainer just teaches all the lecture notes, but when we ask for details, they're not quite willing to tell. But here in SEAFDEC, everyone is very willing to help us."

Yuen Pui Sze
(Hong Kong Special Administrative Region)
Training on Mangrove Crab & Shrimp Hatchery Operations

"I am impressed and thankful for the new learnings I gained about the aquaculture technology and how to communicate to rural communities and I hope that [this] training won't be the last."

Michael E. Salandanan
Aquaculturist, Laguna Lake Development Authority (Philippines)
Training on Community-Based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia

"Before coming to this course, I have heard about sandfish, but I have never seen a sandfish. It is only in SEAFDEC that I see the sandfish, touch the sandfish, and ate the sandfish in Molocaboc. It is a very good experience."

Antony Vrayen
(Sri Lanka)
Training on Sandfish Seed Production, Nursery, and Management

" The training has a personal touch, it's like learning by doing.... Here in SEAFDEC, I feel very comfortable. The people are very approachable. They don't mind that they are the course teacher, and we are the trainees. They are very open about techniques, about technology, and willing to share the information."

Chinnasamy Ravichandran
Aquaculture Consultant (India)
Training on Sandfish Seed Production, Nursery, and Management

"We learned a lot from the history to the trends, the status, problems to be encountered, as well as future aspects. SEAFDEC is very good at accommodating us; they have shared their technologies so that our regions can give the production that the country needs, increasing the capability of every regional office."

Phillip John Foronda
BFAR Region 1 (Philippines)
Training on Micropropagation & Nursery Operations of Kappaphycus

SCAN ME!
Fisheries officers of eight countries from Africa, Asia and Oceania spent 16 days training at SEAFDEC/AQD in the Philippines hoping to improve the fish farming industries in their respective countries. Get a glimpse of the 2018 Training Course on Inland Freshwater Aquaculture by scanning the QR Code.

Press conference. Local media interview the Chief at the sidelines of the 45th anniversary program of SEAFDEC/AQD.

Information Dissemination & 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. The Library also disseminates in-house and external publications of researchers through the online Institutional Repository. FishWorld, SEAFDEC/AQD's museum-visitor center receives thousands of visitors annually and promotes science and environment education.

Science Papers in Journals and Proceedings

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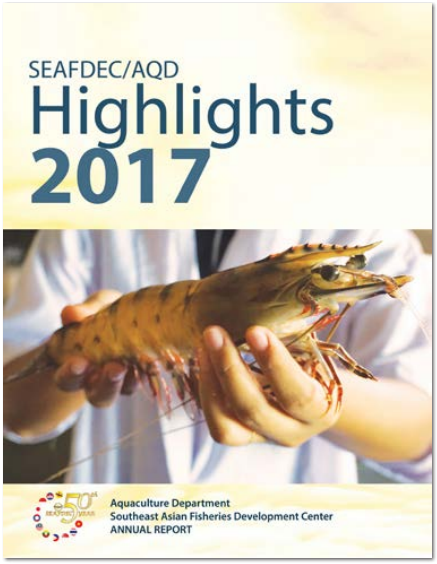
Publications

SEAFDEC/AQD produced a new edition of a farmer-friendly manual on mangrove crab hatchery, two new brochures on mangrove red snapper and sea cucumber culture, and a flyer on milkfish sexing technique. Two promotional brochures were also produced for the Laboratory Facilities for Advanced Aquaculture Technologies and the analytical services available at SEAFDEC/AQD. Other brochures received minor updates. A total of 21,000 copies of technical and scientific materials were printed in 2018. Of these, about 8,260 during the year.

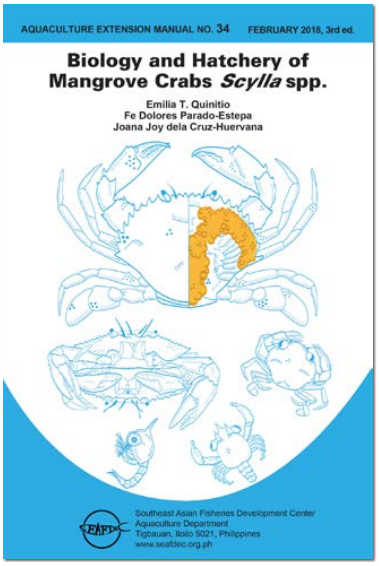
The *AQD Matters* newsletter continued to be released every two months. A special issue was also produced to commemorate SEAFDEC/AQD's 45th anniversary.

Annual Report



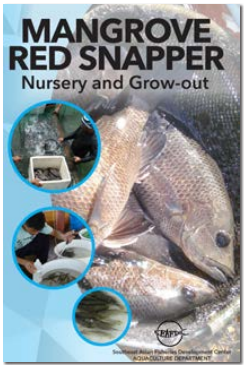
Highlights 2017 is SEAFDEC/AQD's annual report updating on its accomplishments and progress for the year 2017

Extension Manual



The 3rd edition of the *Biology and Hatchery of Mangrove Crabs* Scylla *spp.* (AEM 34) builds upon the 2nd edition published in 2008

Brochures and flyers



Brochures on mangrove red snapper and sea cucumber production were added to the existing lineup of commodity brochures. A flyer on the manual sexing of milkfish was produced for use in onsite trainings. Brochures were also produced (right) to promote the Laboratory Facilities for Advanced Aquaculture Technologies and the different analytical services offered at SEAFDEC/AQD.

Newsletter

The AQD Matters newsletter continued to be issued biomonthly to update on the latest developments in SEAFDEC/AQD. This year, a special issue was published for the Department's 45th anniversary.

Digital Libraries Donated to Fisheries Schools

Digital fisheries library devices, each containing over 26,000 aquatic and marine science publications, were donated to 14 state colleges and universities from around the Philippines.

The digital libraries, hosted in a flash drive and Wi-Fi router powered by the Library Box software, are composed of the collection of selected member libraries of the International Association of Aquatic and Marine Science Libraries and Information Centres (IAMSLIC) of which the SEAFDEC/AQD Library is a member.

Stephen Alayon, acting head of SEAFDEC/AQD's Library and Databanking Section said the device will give students access to the IAMSLIC collection even in places where there is intermittent or no internet connection.

Representatives from recipient state colleges and universities pose with SEAFDEC/AQD officials during the turnover of the IAMSLIC Digital Fisheries Library. Inset is the device containing the aquatic and marine science electronic publications.

"The library of fisheries schools will just switch on the gadget and the students can download the materials to their mobile phones as long as it's a smartphone," Alayon added.

With only half of its 128-gigabyte storage capacity used, he also said they intend to add more publications in the future as they continue to digitize SEAFDEC publications.

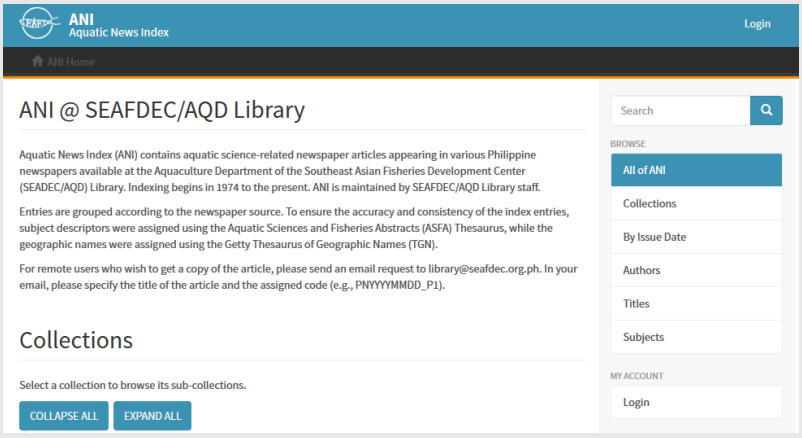
The devices, funded by SEAFDEC/AQD, were turned over to representatives of the colleges and universities during its Book Launching Ceremony on 12 July 2018.

Aquatic News Index launched

An online database indexing aquatic science-related news articles appearing in various Philippine newspapers has been launched for public access during the 27th Book Launching on 12 July 2018.

The Aquatic News Index, nicknamed ANI as an allusion to the Filipino word for harvest, is an initiative of the SEAFDEC/AQD Library to improve the accessibility of current and historical news articles on aquatic sciences and to preserve them in digital form.

The SEAFDEC/AQD Library has already started indexing beginning with their collection of aquaculture and aquatic news clippings which they have accumulated since 1974. The aquaculture news index may now be accessed through the link, ani.seafdec.org.ph.



A screenshot of ANI's home page

Internet Presence

SEAFDEC/AQD WEBSITE

63,159
2018 UNIQUE VISITORS

Most visitors come from English-speaking countries such as the Philippines and the United States. Translation tools are available for non-English speakers.

345K
2018 PAGE VIEWS

The most-viewed page is the home page (19%) followed by the training schedule (5%), the price list of fry and fingerlings (5%), and the overview of mangrove crab culture (4%).

INSTITUTIONAL REPOSITORY

1.78M
2018 DOWNLOADS

Top three most downloaded documents are chapters from the Laboratory manual of standardized methods for antimicrobial sensitivity tests which was published back in 2004.

3,247
ARCHIVED ITEMS

The figure is cumulative since 2011. For 2018, 141 items were archived.

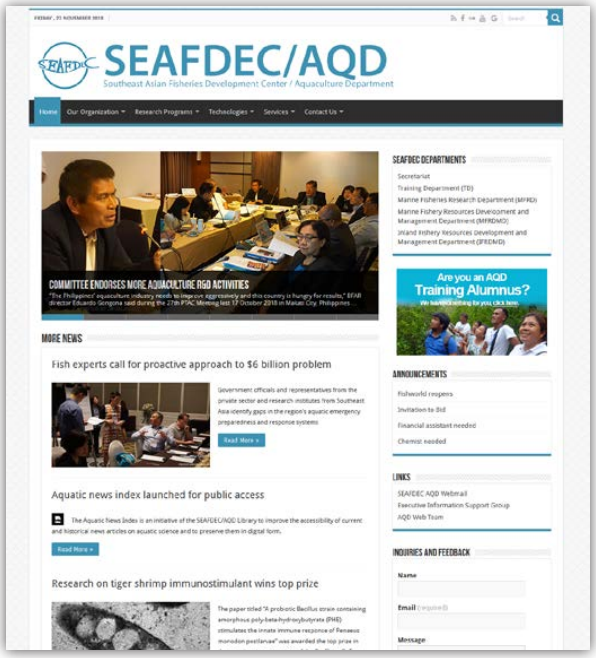
SOCIAL MEDIA

13,531
TOTAL FACEBOOK LIKES

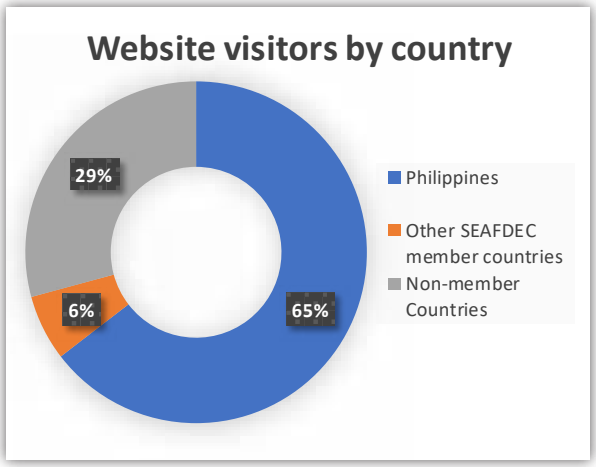
Combined likes of the Facebook pages of SEAFDEC/AQD (main), SEAFDEC/AQD Library, and FishWorld

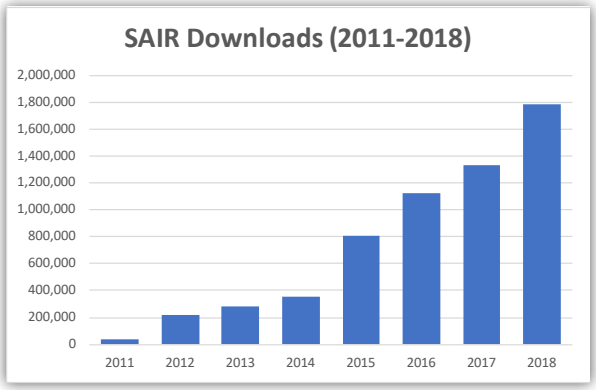
172K
2018 YOUTUBE VIEWS

The offical SEAFDEC/AQD video channel at YouTube continued to gain views, mostly from instructional videos on the farming of aquaculture commodities



The SEAFDEC/AQD website as of December 2018





Mass Media

Information dissemination through mass media continued to be ramped up in 2018. A total of 40 official press releases were sent to different media outlets. In all, SEAFDEC/AQD had 68 recorded appearances in newspapers/magazines and 50 appearances in websites.

Philippine Daily Inquirer
Guimaras site closes door to tourists (24 May 2018, page A10)

The Philippine Star
DOST, schools, local gov't set up mangrove crab hatcheries (17 May 2018, page B5)

Manila Bulletin
Project to push mud crabs production in PH (3 May 2018, page B13)

Increased fish production (23 July 2018, page 12)

Philippine News Agency
14 SUCs avail of free virtual fishery library devices (13 July 2018, page 12)

Aquatic news index now available online (16 July 2018)

Philippine Information Agency
SEAFDEC/AQD Scientist to boost shrimp farming (8 January 2018)

SEAFDEC/AQD to offer free training for fishery graduates (24 January 2018)

SEAFDEC targets 15 PHL towns for multi-species hatchery (25 April 2018)

PTV News
Foreigners receiving marine fish hatchery training at SEAFDEC (14 July 2018)

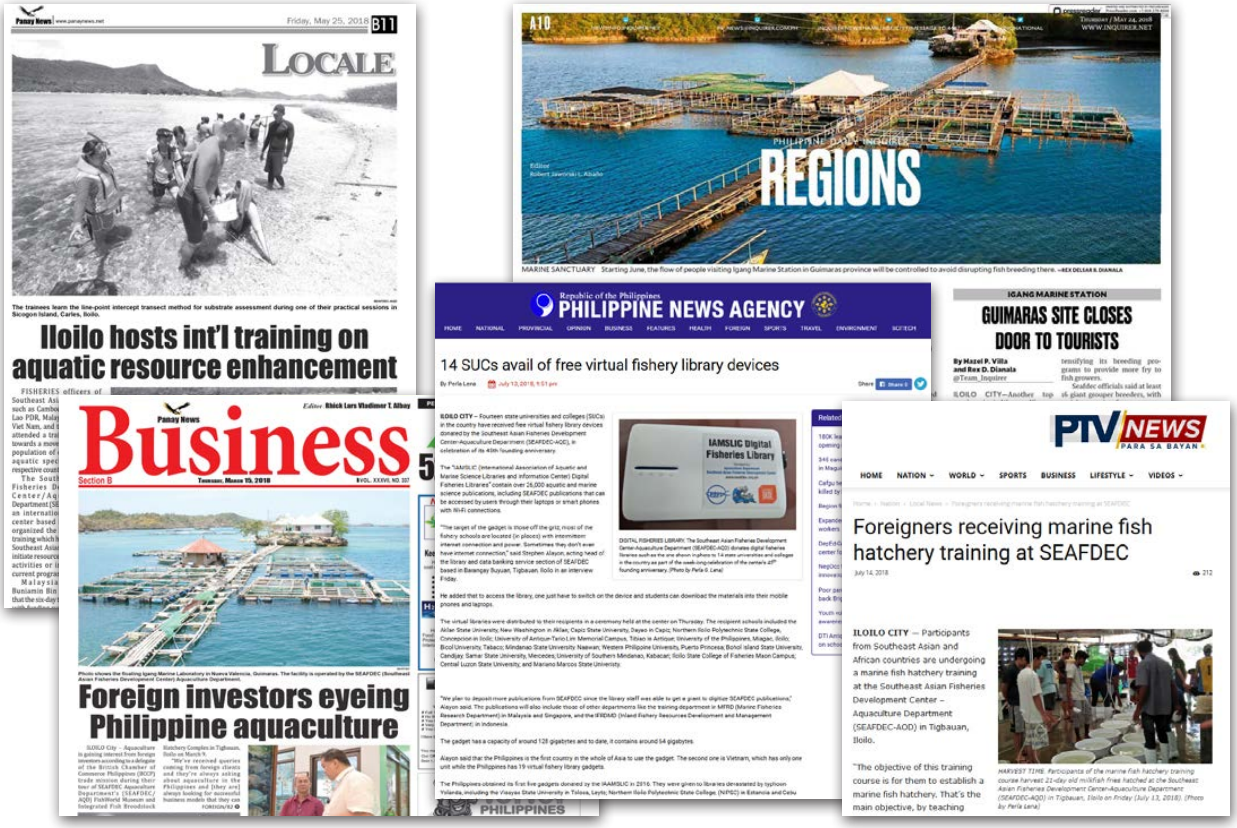
Panay News
PH allots P10.5M for SEAFDEC/AQD to establish 15 pilot multi-species hatcheries (1 March 2018, page B11)

Foreign investors eyeing Philippine aquaculture (15 March 2018, page B1)

DA turns over P460M experimental facilities to SEAFDEC/AQD (8 May 2018, page B1)

The Daily Guardian
SEAFDEC/AQD Advice Growers told to avoid stocking shrimps during cold months (2 February 2018, page B1)

SEAFDEC, PENRO Guimaras release healed sea turtles (16 July 2018, page 17)



Some of SEAFDEC/AQD's appearances on print media

Exhibitions

For 2018, SEAFDEC/AQD organized two exhibitions and participated in three. These exhibitions were mainly to promote its sustainable aquaculture technologies and to distribute aquaculture books, manuals and brochures that it produced. In all, the exhibitions attracted over 20 thousand walk-in guests. About half of these visitors were logged during a six-day exhibition of the SEAFDEC/AQD Aquaculture Week which was situated in the largest mall in Iloilo City. A large number of visitors were also logged in the Regional Science and Technology Week exhibition, organized by the Philippine Department of Science and Technology.

SEAFDEC/AQD's Aquaculture Week Exhibition at SM City Iloilo


DOST Regional Science and Technology Week


SEAFDEC/AQD Aquaculture Week

2nd National Bangus Congress

2nd Agri-Aqua Investment Forum

Exhibitions participated in or organized by SEAFDEC/AQD in 2018

Exhibition or Event	Exhibit Highlight	Date	Venue
AQD Fellowship Night	AQD Memoirs	13 July 2018	TMS
SEAFDEC/AQD Aquaculture Week	Aquaculture and Food Security	1-6 August	Iloilo City
DOST Regional Science and Technology Week	Mangrove crab and single oysters	29-31 August	Roxas City
2nd National Bangus Congress	Milkfish	27-28 September	Iloilo City
2nd Agri-Aqua Investment Forum	Tiger Shrimp and milkfish	7-9 November	Iloilo City

FishWorld

FishWorld, AQD's visitor center and museum of aquatic biodiversity, received 12,275 guests in 2018. The Internship and On-the-Job Training Program of FishWorld, listed 99 student participants from five high schools. The annual Aquaculture Week was participated in by seven high schools and 11 elementary schools with about 130 students and 77 coaches joining the various Sci-Art Contests. FishWorld also works on the conservation of endangered megafauna. For 2018, 14 sea turtles were brought to FishWorld after being rescued from fish traps or found along the beach. Six of these turtles were released (four with tags) after tagging, two are under rehabilitation, while six died and were preserved.

Saving the Ocean through Sing and Dance

Ocean Floor Painting Contest

Ocean Literacy Quiz

Seafood Festival

Site survey. The Chief (center in magenta) leads a team assessing a proposed hatchery site in Nasipit, Agusan del Norte.

Extension & Services

SEAFDEC/AQD works closely with different sectors, especially the government, to provide technical expertise towards the development of the aquaculture industry. Several facilities also operate in support of the research and development activities. These facilities are likewise availed by the private sector, the academe and government.

Extension

In collaboration with the Philippine Bureau of Fisheries and Aquatic Resources and local government units, SEAFDEC/AQD conducted a series of site-asessment surveys towards the establishment of multi-species hatcheries around the Philippines in 2018. The establishment of the hatcheries were mandated by legislation (Republic Acts) passed by the Philippine House of Representatives and the Senate and affirmed by the President.

Out of 15 areas surveyed, 10 sites were found to have potential to host multi-species hatcheries. However, the sites are still subject to recommended repairs and improvements. Out of 10 sites, only three have progressed to near completion of the recommended actions including (1) proper acquisition of at least 3,000 sqm. land; (2) establishment of access road; (3) drilling for a freshwater source; and (4) setting up of a 3-phase electrical line. The three feasible sites are in Jabonga, Agusan Del Norte; Lingig, Surigao del Sur; and Del Carmen, Surigao del Norte.

P10-M agreement sealed for planning of 15 hatcheries

To step-up fisheries production in the country, the Bureau of Fisheries and Aquatic Resources (BFAR) tapped the Southeast Asian Fisheries Development Center (SEAFDEC) in a P10 million project to conduct surveys and prepare development plans for the establishment of 15 multi-species fish hatcheries in 7 provinces around the Philippines.

Under an agreement signed in 8 February by BFAR national director Eduardo Gongona and SEAFDEC Aquaculture Department chief Dan Baliao, SEAFDEC will assess pre-identified project sites, recommend hatchery technologies to be deployed, outline production cycles, produce site development plans as well as detailed blueprints for facility design.

The hatcheries to be built in the provinces of Agusan del Norte, Albay, Cebu, Lanao del Norte, Surigao del Norte, Surigao del Sur, Quezon and Zamboanga del Norte, are seen to shore up the supply of fingerlings for fish farmers.

Site surveys to be conducted by SEAFDEC/AQD will include the conduct of water and soil analyses and stakeholder interviews. Environmental parameters in the respective areas will be considered as well as the current fingerling requirements and the potential market for other aquaculture commodities.

While BFAR is mandated to supervise the establishment of these legislated multi-species hatcheries before turning them over to the local government after a training and phasing-in program, the agreement recognized the "necessity to pool resources, activities and technical expertise" of BFAR and SEAFDEC/AQD to "attain the vision of developing sustainable aquaculture and revitalize the fishery and aquatic resources in the country."

Site survey at Lingig, Surigao del Sur

Site survey at Hinatuan, Surigao del Sur

Feasibility study for multi-species hatcheries turned over to BFAR

SEAFDEC/AQD Chief Dan Baliao led the turning over of the feasibility studies for legislated multi-species hatcheries as stipulated in the agreement between SEAFDEC/AQD and the Bureau of Fisheries and Aquatic Resources (BFAR).

Caraga Region may soon start the P30-35 million per hatchery structure at two recommended sites in Lingig, Surigao del Sur and Del Carmen, Surigao del Norte.

The hatcheries are designed to produce 25 million milkfish fry annually and has the flexibility to allow fry production of other marine species, depending on the discretion of the LGU that will eventually take over the ownership and operation of the hatchery.

Options will be available on whether the hatchery would be operated for fry production of one species at any time or the apportioning of tanks to allow simultaneous fry production of different species.

Turn-over of feasibility study to BFAR representatives and Surigao local government

The feasibility study was submitted in compliance with RA 10825 enacted during the 16th Congress establishing a multi-species marine hatchery in various regions of the country.

The feasibility study includes site selection, hatchery technology for alternate species, implementing schedule, risk assessment, environmental impact, facility design and engineering, personnel requirements and economic and financial analysis.

The operation of these multi-species marine hatcheries have been integrated into the "Bangus Fry Sufficiency Program" launched by DA-BFAR early this year. The program seeks to address the country's dependence on imported milkfish fry reducing importation by about 85 percent.

SEAFDEC/AQD and BFAR will jointly pool resources and technical expertise to implement activities aimed at attaining objectives of the said legislation.

Meanwhile, out of 26 areas legislated for the establishment of multi-species hatcheries, 10 were identified to have potential. However, only two of these 10 sites are now ready for implementation.

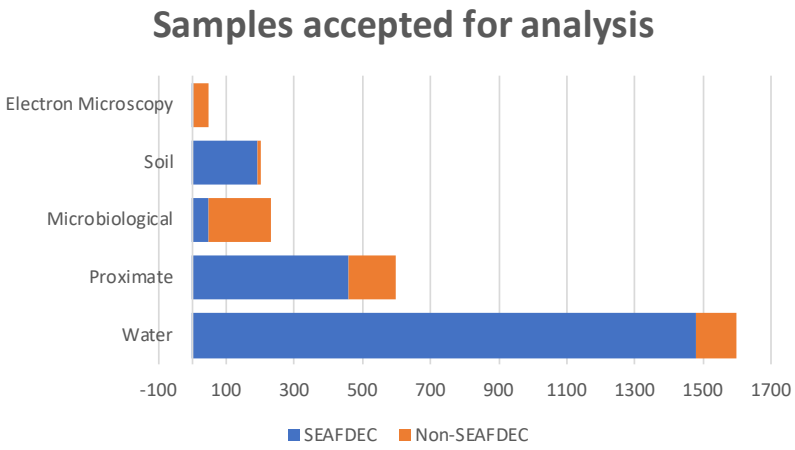
The turnover was done on 28 September 2018, the second day of the "2nd National Bangus Congress" held at the Iloilo Convention Center.

Meeting with the mayor of Nasipit, Agusan del Norte

Water sampling to measure the salinity

Analytical Services

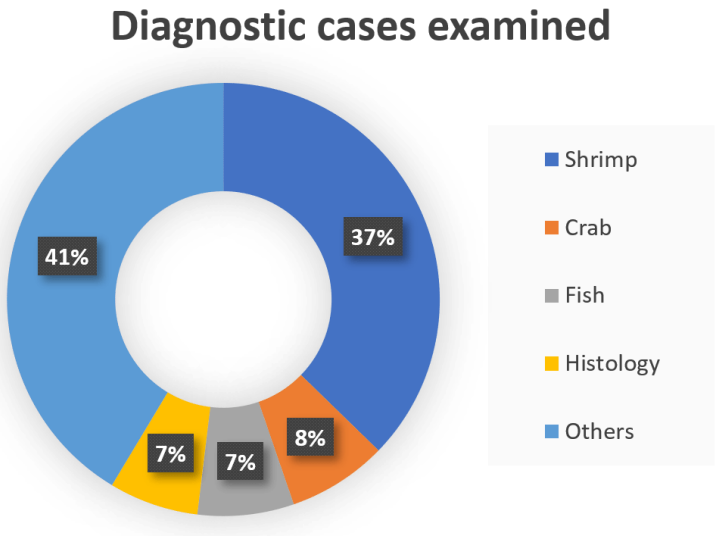
The Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT) conducts proximate, water, soil and microbiological analysis. LFAAT accepted 2,673 samples which were subjected to 2,859 determinations. Most of the samples were analyzed in support of SEAFDEC/AQD's various research programs while some also were submitted by stakeholders from the private sector and the academe. Bulk of the samples analyzed were water (1,597) with ammonia-N being the most-determined parameter. Other services that received samples were proximate analysis (595), microbiological analysis (230), soil (201), and electron microscopy (50).

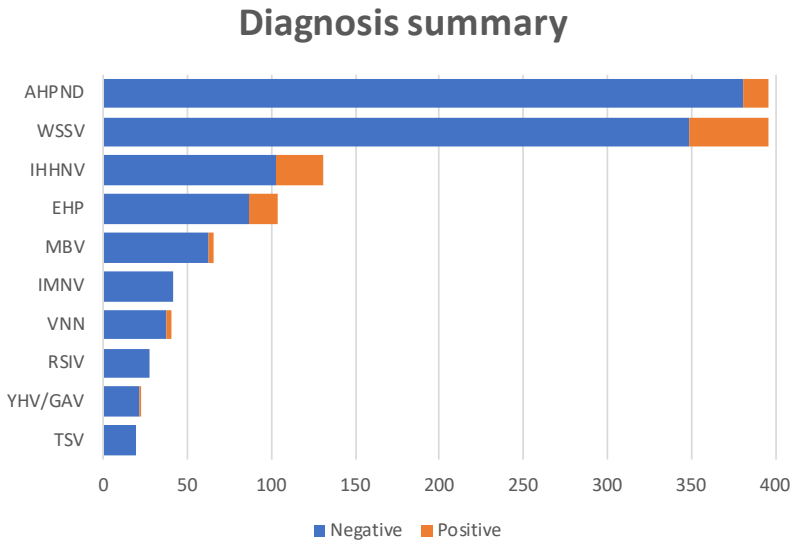


Diagnostic Services

The Fish Health Section handles diagnostic cases for a range of viruses, bacteria and parasites. Diagnostic services catered to 389 cases in 2018, mostly on shrimp (37%). Diseases were detected mainly through polymerase chain reaction (PCR) with 1,242 samples analyzed. White spot syndrome virus (WSSV) and Acute Hepatopancreatic Necrosis Disease (AHPND) were of equal interest, both with 396 samples analyzed.

Bacterial count was also done on 206 samples, bacterial identification done for 185 samples, and parasite detection for 52 samples. Meanwhile, the Microtechnique Laboratory released 490 slides and 70 blocks from 779 samples received.





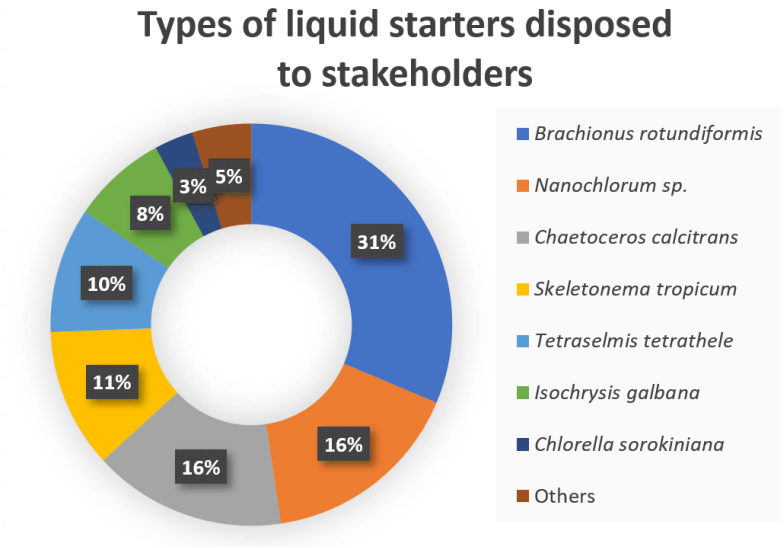
Larval Food Laboratory

To support the research and production activities of AQD, the larval food laboratory served 22,375 liters (live) and 19.84 kg (paste) of microalgal and rotifer starters for oyster, sandfish, abalone, grouper, annelids, *Artemia* biomass, *Proales*, copepods, shrimp and crab hatcheries. For *Artemia* biomass, 46.06 kg (wet weight) were prepared for the seahorse, crab and FishWorld and marine fish requirements.

Maintenance of algal culture collection at the Larval Food Laboratory

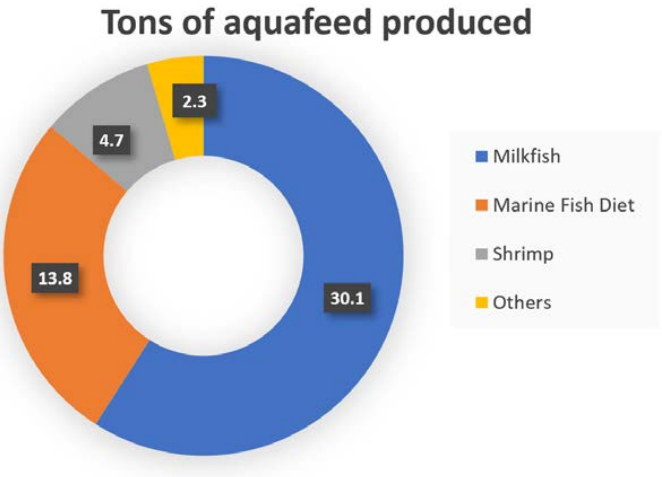
The laboratory also catered to 299 clients from the private sector (local, 43.5%; foreign,6.4%), academe (29.1%), and government institutions (21%). The items sold included 1,411 liters of liquid microalgal/rotifer/starters, 200g *Artemia* cysts, 15.2 kg of concentrated microalgal paste, 68 tube cultures, and pre-mixed fertilizers and culture media.

New strains were added to the collection, namely *Brachionus rotundiformis*, *Thalassiosira weissflogii*, *Apocyclops panamensis*.



Feed Mill

Over 50 tons of aquafeeds for various commodities were produced by Feed Mill in 2018. About 71% of these were produced for studies funded by AQD and other agencies. The rest were for external clients which include the academe (researchers and students), the Philippine Bureau of Fisheries and Aquatic Resources, private hatcheries, and individuals.



Hatchery and Grow-out Production

Different aquatic commodities are produced as byproduct of different research and technology verification and demonstration activities at SEAFDEC/AQD. Milkfish continued to top hatchery production, producing almost 100 million larvae. Over 13 tons of market-size commodities were produced in 2018, mostly milkfish and pompano.

Market-sized commodities produced by SEAFDEC/AQD as research and extension byproducts in 2018

Commodity	Quantity
Milkfish	8,618 kg
Snapper	40 kg
Pompano	4,215 kg
Tilapia	184 kg
Siganid	431 kg
Mangrove crab (adult/soft-shell)	3,719 pcs

SEAFDEC/AQD's hatchery production in 2018 by commodity

Commodity	Quantity (pcs)	
	larvae	fry
Milkfish	96,638,745	1,149,800
Grouper		
Epinephelus coioides	3,575,976	11,258
Epinephelus fuscoguttatus	4,329,792	75
Rabbitfish	6,903,388	41,841
Sea bass	29,527,173	1,220,000
Snapper	72,715,554	128,850
Pompano	4,387,035	265,750
Bighead carp*		2,244,000
Tilapia*		1,474,536
Mangrove crab	1,314,500 megalopae	615,235 crablets
Abalone	10,153,701 veliger larvae	209,921 juveniles
Shrimp/prawn		postlarvae/juveniles
Giant freshwater prawn*		91,430
White shrimp*		49,000
Tiger shrimp*		492,600

*based on sales data

Library Services

The present collection of SEAFDEC AQD Library stands at 45,622 titles and 76,654 copies of monographs, serials, vertical files, and non-print materials. These were available for use and could be searched online through the AQD Library online public access catalog (OPAC). The OPAC was visited by a total of 1,105 global searchers. In addition, the library offers access to the following databases: ASFA, Springer, ProQuest Central, and TEEAL.

The Library served 1,594 readers, 97% of whom were from different academic institutions in the country, students, faculty, and researchers . The remaining percentage was composed of visitors from fisheries-related agencies in SEAFDEC member countries, private sectors, and non-government institutions. Moreover, a total of 5,941 (4,635-SAIR; 1,306- in-house) document requests were catered from about 2,765 (2,467-SAIR; 298- in-house) individuals. Seventy-eight percent of the documents requested were placed thru the SEAFDEC/AQD Institutional Repository (SAIR). Majority of the requesters were from the Philippines, India, Malaysia, Indonesia, USA, Singapore, and Thailand, United Kingdom, Sri Lanka, Denmark, Germany, etc. While the remaining percentage of the documents requested were in person, and remotely, thru email, phone, chat, and Facebook messenger, the majority by SEAFDEC/AQD employees.

New Collaborations

Academe

Partner Institution	Nature of collaboration	Period
China-ASEAN Center for Joint Research & Promotion of Marine Aquaculture Technology	Establish a framework for an effective and mutually beneficial cooperation on crustaceans and fishes	2018-2020
Ocean University of China	Establish a framework for the effective and mutually beneficial cooperation on marine aquaculture, fisheries, seaweed	2018-2023

Government and Non-Government Organizations

Partner Institution	Nature of collaboration	Period
Bureau of Fisheries and Aquatic Resources	Conduct surveys and prepare development plans for the establishment of 15 multi-species fish hatcheries in 7 provinces around the Philippines	2018
Bureau of Fisheries and Aquatic Resources	Conduct surveys and trainings towards establishing mangrove crab seed banks, nurseries and grow-out production farms in the Catanduanes province	2018
Food and Agriculture Organization of the United Nations	Digitization of documents published by SEAFDEC for deposition in open-access repository and preparation of ASFA records	2018 - 2019
Department of Fisheries, Thailand – Aquatic Animal Health Research and Development Division	Collaboration in the efforts of conducing the "ASEAN Regional Technical Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia,"	2018
Japan-ASEAN Integration Fund	Conduct of the "ASEAN Regional Technical Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia."	2018

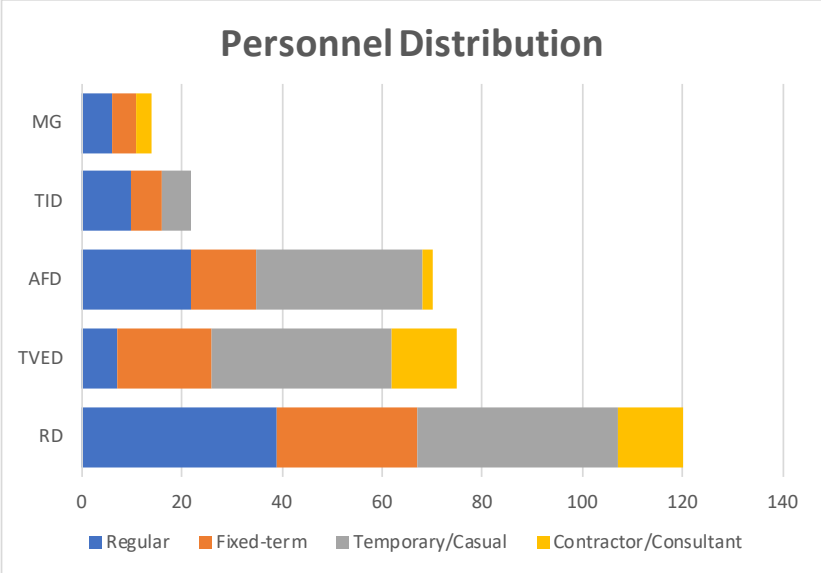
New blood. Employees who joined the ranks of SEAFDEC/AQD within the past 10 years during a Fellowship Night in July.

Human Resources & Finance

Various avenues were provided to enhance the capacity and promote the productivity of personnel who are behind the activities and accomplishments of the organization. Sound management of fiscal resources is imperative to maximize the output of activities and their benefit to stakeholders.

Personnel Distribution

As of end of 2018, SEAFDEC/AQD's personnel numbered 301 composed of 84 regular employees, 71 fixed-term staff, 115 casuals, and 31 contractors/consultants. The Research Division (RD) had the most staff (120) assigned to it, followed by the Technology Verification and Extension Division (TVED) with 75, Administration and Finance Division (AFD) with 70, and the Training and Information Division (TID) with 22. The Management Group involved 14 personnel.



Mori is new Deputy Chief

Dr. Koh-ichiro Mori started his tour of duty as SEAFDEC/AQD's deputy chief on the 1st of April 2018.

Dr. Mori used to work at the Research Center for Fish Diseases, National Research Institute of Aquaculture in Japan before joining SEAFDEC. As the Director, he was involved in planning and implementation of research projects.

Dr. Mori earned his PhD degree at the Hiroshima University, Japan in 1995 where he also got his Masteral and BS degrees.

Dr. Mori started as a researcher in Japan Sea Farming Association where he focused on fish disease-related researches. His eight-year stint there resulted in several publications. Among his major outputs were on viral nervous necrosis in marine fishes and white spot disease in kuruma prawn. He also did studies on seed production of grouper, striped jack, kuruma prawn, swimming crab and octopus.

In 2003, Dr. Mori worked as a Senior Researcher at the Aquatic Animal Health Division of the National Research Institute of Aquaculture. He continued to do more researches related to fish diseases as well as seed production especially on grouper. He worked there until 2010.

Dr. Mori had a short stint at the Headquarters of Japan Fisheries Research and Education Agency from 2010-2012. As a Research Coordinator, he took charge in planning and coordinating of research projects related to aquaculture and genetic analysis. Even with short stay, he was able to continue publishing papers on fish diseases.

In 2012, Dr. Mori was back at the National Research Institute of Aquaculture where he was Head of the Pathogen Research Group at the Aquaculture Animal Health Division. In 2014, he eventually became Director of the Research Center for Fish Diseases.

Dr. Mori took over the post of Dr. Chihaya Nakayasu who was SEAFDEC/AQD deputy chief from 2016 to March 2018.

Staff Development

To enhance and upgrade the knowledge and skills of research, information, and administrative personnel, SEAFDEC/AQD's Staff Development Program provides for the attendance and participation of qualified and deserving staff in local and international meetings and conferences. This year, 19 personnel were sent to five international and 14 local events. Of these, four presented papers in the oral category of symposiums and conferences. One was also allowed one week leave with pay to prepare for a comprehensive examination.

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

Event	Date	Location
Training on Quality Assurance in Chemical Analysis	04-06 April 2018	Quezon City, Philippines
1st Academia Sinica-University of San Agustin Bilateral Symposium	12-13 April 2018	Taipei, Taiwan
Asia Pacific Aquaculture Conference 2018	23-26 April 2018	Taipei, Taiwan
The Essentials on Management Skills in the Age of Disruption	29-30 May 2018	Pasig City, Philippines
Congress of Southeast Asian Librarians	2-5 May 2018	Naypyitaw, Myanmar
33rd Chemistry Congress	30 May - 01 June 2018	Pasay City, Philippines
International Symposium on Genetics in Aquaculture XIII	15-20 July 2018	Queensland, Australia
AQUA 2018 Conference and Exposition	25-29 August 2018	Montpellier, France
49th National Convention and 68th Foundation Anniversary of the Occupational Health Nurses Association of the Philippines	06-07 September 2018	Manila, Philippines
Seminar on Quality Assurace and Compliance Part - 2	06-07 September 2018	Quezon City, Philippines
2nd National Bangus Congress	27-28 September 2018	Iloilo City, Philippines
Agri/Food/Aqua Link 2018	04-06 October 2018	Pasay City, Philippines
3-Day CPD on Tour EXCL Seminar	11-13 October 2018	Roxas City, Philippines
44th Annual Conference of the International Association of Aquatic and Marine Science Libraries and Information Center	21-25 October 2018	Entebbe, Uganda
43rd National Convention of the Institute of Integrated Electrical Engineers of the Philippines	14-17 November 2018	Pasay City, Philippines
8th Annual Auditor's Forum	11-12 December 2018	Cebu City, Philippines

Summary of Grants Received

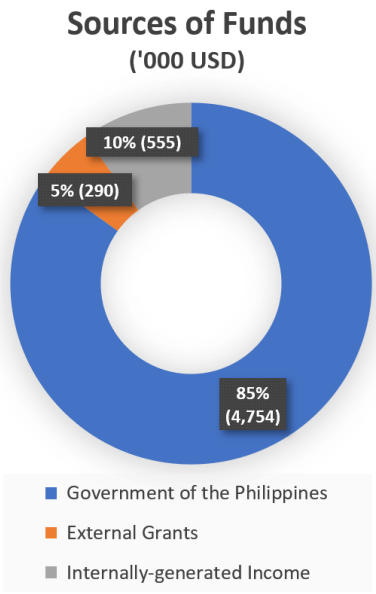
Organization	Scope	Amount (US Dollar)
Australian Center for International Agricultural Research (ACIAR)	Developing technologies for giant grouper aquaculture in Vietnam, the Philippines and Australia	23,460
James Cook University (ACIAR)	Expansion and Diversification of Production and Management Systems for Sea Cucumbers in the Philippines, Vietnam and Northern Australia	3,703
James Cook University (ACIAR)	Increasing technical skills supporting community-based sea cucumber production in Vietnam and the Philippines	17,347
Japan Asean Integration Fund (JAIF)	Regional Technical Consultation on Aquatic Emeregency Preparedness and Response System for Effective Management of Transboundary Disease	89,641
Japan International Research Center for Agricultural Sciences (JIRCAS)	Value-Adding and Improving economic efficiency & benefits in small holder IMTA Milkfish Mariculture in Guimaras, Philippines	7,172
Japan International Research Center for Agricultural Sciences (JIRCAS)	Development of low fish meal feed for aquaculture using alternative resources	18,764
Japan International Research Center for Agricultural Sciences (JIRCAS)	Demonstration and Verification of Sustainable and Efficient Aquaculture Techniques by Combination of Multiple Organisms	11,354
Bureau of Fisheries and Aquatic Resources (BFAR)	Establishment of Mangrove Crab Seedbanks, Nurseries and Grow-out Production Farms in the Province of Catanduanes	3,824
Bureau of Fisheries and Aquatic Resources (BFAR)	Establishment of Multi-Species Hatchery/Nursery Facilities	38,241
Japan Asean Integration Fund (JAIF)	Nursery Rearing Trials of Anguilid Glass Eels for Culture	10,965
The Scottish Association for Marine Science (SAMS)	Global Seaweeds STAR	25,172
Food and Agriculture Organization of the United Nations (FAO)	Digitisation, Open Access Deposition and the Provision of URL to existing ASFA Records	4,617
National Fisheries Research and Development Institute (NFRDI)	Collaborative Projects between NFRDI and SEAFDEC/AQD on Aquaculture Feed Development	38,241
TOTAL		**292,501**

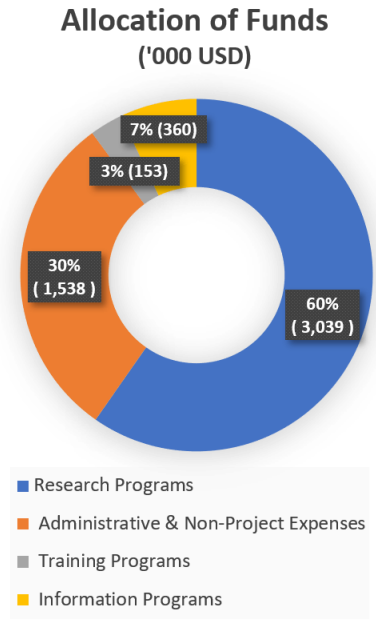
Statement of Financial Position

(US Dollar '000)		
	As of Dec. 31, 2018	As of Dec. 31, 2017
ASSETS		
CURRENT ASSETS		
Cash and cash equivalents	3,092	3,076
Accounts Receivables	189	112
Materials and Supplies	19	25
Other current assets	2	2
Total Current Assets	3,302	3,215
NON-CURRENT ASSETS		
Cash investments	264	272
Other non-current assets	265	266
Total Non-current Assets	529	538
TOTAL ASSETS	3,831	3,753
LIABILITIES		
CURRENT LIABILITIES		
Accounts Payable	366	617
Funds Held-in-Trust	254	259
TOTAL LIABILITIES	620	876
NET ASSETS		
Designated	3,211	2,877
Undesignated	-	-
Unrealized Gain on AFS		
Financial Assets		-
TOTAL NET ASSETS	3,211	2,877
TOTAL LIABILITIES AND NET ASSETS	**3,831**	**3,753**

STATEMENT OF REVENUES & EXPENDITURES (US Dollar '000)		
	Period ending	Period ending
	As of Dec. 31, 2018	As of Dec. 31, 2017
REVENUES		
Contributions / Grants	5,045	4,705
Other Income	534	517
TOTAL REVENUE	5,579	5,222
EXPENDITURES		
Research Programs	3,039	2,669
Training Programs	153	114
Information Programs	360	318
General Administrative and Non-Project Expenses	1,538	1,697
TOTAL EXPENDITURES	5,090	4,798
BALANCE	489	424

Note: The 2018 figures stated on this page are unaudited pending the completion of an external auditor's report.





Philippine govenment turns over biotech complex to AQD

The Philippine Bureau of Fisheries and Aquatic Resources (BFAR) formally turned over a biotechnology complex to SEAFDEC/AQD last 7 May 2018 as Chief Dan Baliao signed a document acknowledging receipt of the Laboratory Facilities for Advanced Aquaculture Technologies.

The facilities, already hosted by SEAFDEC/AQD since 2002, was a JPY 895 million (P431 million in 2001) bilateral project between the Philippine and Japanese governments as grant aid through the Japanese International Cooperation Agency (JICA) with the Philippine Department of Agriculture (DA) as recipient. The complex included laboratories for endocrinology and genetics, feed technology, algal production and microbiology.

Acknowledgment of facilities and equipment of the Laboratory for Advanced Aquaculture Technologies or Biotech Laboratory

BFAR was represented by Drusila Bayate, executive director of the National Fisheries Research and Development Institute while SEAFDEC/AQD deputy chief Dr. Koh-ichiro Mori represented the Government of Japan.

Buildings named after prime movers

The prime movers in the establishment of SEAFDEC/AQD were honored in dedication ceremonies as two buildings at the Tigbauan Main Station were named after them.

The Administration Building is now named as the Dr. Quiterio F. Miravite Hall while the Nutrition and Reproductive Physiology Building is now the Dean Domiciano K. Villaluz Hall, in honor of these men who were instrumental in the establishment of SEAFDEC/AQD in the Philippines in 1973.

Markers dedicating the buildings were unveiled by SEAFDEC/AQD officials and representatives of the families of Dr. Miravite and Dean Villaluz on 13 July 2018 as a highlight of SEAFDEC/AQD's 45th Anniversary Celebration.

Unveiling of marker during the dedication of the Dean Domiciano K. Villaluz Hall

Dr. Miravite was recognized for his vision and tireless efforts in securing funds for the construction and operation of the research and administrative complexes in Tigbauan, Iloilo; Leganes, Iloilo; Pandan, Antique; Igang, Guimaras; and Binangonan, Rizal.

Meanwhile, Dean Villaluz was cited for his pivotal role as the first Department Chief and in setting the research direction of SEAFDEC/AQD and for his guidance to the pioneering staff in undertaking research and development projects for milkfish and tiger shrimp.

2018 Heads of Offices

Executive Committee

Chief	Mr. Dan Baliao
Deputy Chief	Dr. Chihaya Nakayasu (until 31 March) Dr. Koh-ichiro Mori (beginning 1 Apri)
Head, Research Division	Dr. Leobert de la Peña
Head, Technology Verification & Extension Division	Mr. Dan Baliao
Head, Training & Information Division	Dr. Edgar Amar
Head, Administration & Finance Division	Ms. Amelita Subosa

Station Heads/OIC

Binangonan Freshwater Station	Dr. Maria Lourdes Aralar
Dumangas Brackishwater Station	Mr. Victor Emmanuel Estilo
Igang Marine Station	Mr. Mateo Paquito Yap
Manila Office	Ms. Anna Maria Josefa Ortiz

Program Leaders

Quality seed for sustainable aquaculture	Dr. Maria Rowena Eguia
Healthy and wholesome aquaculture	Dr. Mae Catacutan, Dr. Eleonor Tendencia
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 (until 31 March) Dr. Koh-ichiro Mori (beginning 1 Apri)

Section Heads/OIC

Research Division

Breeding and seed production	Dr. Shelah Mae Ursua
Fish health	Dr. Eleonor Tendencia
Nutrition and feed development	Dr. Roger Edward Mamauag
Farming systems and ecology	Dr. Jon Altamirano
Socioeconomics	Dr. Nerissa Salayo

Technology Verification and Extension Division

Technology verification	Dr. Roger Edward Mamauag
Extension and packaging	Ms. Erish Estante

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. Sunshine Mae Salonga
Budget-cashiering	Ms. Jiji Rillo
Accounting	Ms. Jo Anne Coronel

TVDD is now TVED

As approved by the SEAFDEC Council during its Fiftieth Council Meeting on 26-30 March 2018, the Technology Verification and Extension Division (TVED) replaces Technology Verification and Demonstration Division (TVDD).

This division shall be responsible for the translation of research results into adoption-ready production systems. The Demonstration and Packaging Section will be renamed as Extension and Packaging Section (EPS). EPS will handle technology promotion and technical assistance services.

Sunrise at the Binangonan Freshwater Station

Milkfish, *Chanos chanos*, fingerlings displayed at the Aquaculture Week 2018 exhibition

AQUACULTURE DEPARTMENT
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 Terrengganu, 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.