



SEAFDEC/AQD
Highlights
2019

ANNUAL REPORT

Southeast Asian Fisheries Development Center
AQUACULTURE DEPARTMENT

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2019 SEAFDEC/AQD HIGHLIGHTS

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Cover photo: Tiger shrimp, *Penaeus monodon*, harvested at the Dumangas Brackishwater Station in November 2019. (Photo by JF Aldon)

Milkfish fry produced at SEAFDEC Aquaculture Department where production is being ramped up, through environmental manipulation and construction of new facilities, to help the Philippine Government meet the shortage of seeds in the Department's host country (see page 8).



Message of the Chief



This is a year where we have begun to reap the fruits of our concrete actions to develop the aquaculture industry, especially for our host government. While there is still much to do, we celebrate the milestones we have achieved in 2019, knowing that we are in the right trajectory to improve fish production and contribute to the livelihood of our stakeholders.

Firstly, we celebrate the success of our banner program, Oplan Balik Sugpo. This year, our new shrimp hatchery was able to produce high-quality postlarvae which were then stocked in our newly-rehabilitated and reconfigured ponds at the Dumangas Brackishwater Station. Using simple environment-friendly technologies and strict biosecurity, we harvested more than seven tons of market size tiger shrimp in October and November 2019. This successful demonstration of tiger shrimp culture is just the beginning. We continue to refine our protocols in nutrition, seed production, grow out, and health management as more demonstration runs are in the pipeline.

We were also able to hit an important milestone in our

manpower development program. The training graduates we fielded to upstart the Bureau of Fisheries and Aquatic Resources (BFAR) hatchery in Sagnay, Camarines Sur produced and sold their first batch of almost half a million milkfish fry in September 2019. We look forward to more government and private hatchery facilities that will finally be made operational and productive as we intend to train more fisheries graduates and send them out to exercise their skills in the field.

Another milestone this year is the commencement of the construction of legislated hatcheries in Lingig, Surigao del Sur and Del Carmen, Surigao del Norte. Concrete structures for the hatchery are already rising in these sites and, soon, will be producing much-needed seedstock for our fish farms. We continue to evaluate other sites and work hand-in-hand with BFAR as we prepare more detailed feasibility study reports and engineering designs to them.

The field testing of our cost effective feed formulations is also in full swing in different aquaculture sites in the Philippines, in collaboration with the National Fisheries Research and Development Institute and BFAR. Along with this, we have upgraded our feed mill by quadrupling its capacity to produce the experimental feeds needed by the project.

We also celebrate the first patent granted to SEAFDEC/AQD by the Intellectual Property Office of the Philippines in October. The patent recognizes the inventiveness and novelty of the hatchery technology for silver

perch developed by our scientist, Dr. Frolan Aya. We also recognize the dedication of our Innovation and Technology Support Office that facilitated the registration of the patent.

With 50 active research and development projects in 2019, SEAFDEC/AQD was indeed busy tackling multifarious challenges in aquaculture across different fronts. At the proper time, in due season, we will reap the fruits of science-based development, if we do not give up. Our stakeholders can count on our dedication and determination.

Dan D. Baliao
Chief, SEAFDEC/AQD

2019 News highlights



Project to lower cost of aquafeeds kicks off in Guimaras
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'Baskets' of expectations filled after sandfish training
story on page 50



Revival of tiger shrimp farming gets boost from PH gov't
story on page 12



Japan sponsors training of Iloilo HS science teachers
story on page 50



SEAFDEC/AQD's first patent: hatchery technology to save endemic 'ayungin'
story on page 17



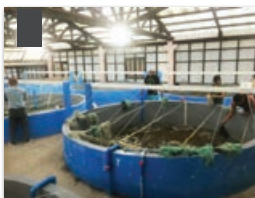
SEAFDEC/AQD science paper wins prestigious award
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New species of polychaete discovered at SEAFDEC/AQD
story on page 19



New harvesting equipment for production of algal paste
story on page 61



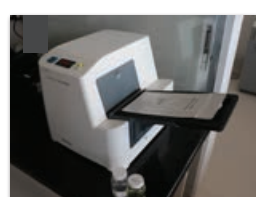
Simple techniques double crablet survival
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Feed mill upgraded to boost production of low-cost feeds
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Environment-friendly tiger shrimp farming pushed
story on page 32



New and improved analytical services at LFAAT
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Info sharing on aquaculture a must in ASEAN
story on page 42



Scientists awarded for contributions to aquaculture
story on page 67

Research & development programs in 2019

FIVE THRUSTS OF SEAFDEC/AQD

Project Title
Fry Sufficiency Program
Development of Cost Effective Feeds
<i>Oplan Balik Sugpo</i> (Operation Black Tiger Shrimp Revival)
Joint Mission For Accelerated Nationwide Technology Transfer Program (JMAN TPP II)
Manpower Development

THEMATIC PROGRAMS

Study Title	Main Proponent	Collaborating Partners
Quality Seed for Sustainable Aquaculture		
1	Development of techniques for sustainable mass production of harpacticoid copepods for marine and crustacean larviculture	MAE Mandario
2	Philippine native catfish (<i>Clarias macrocephalus</i>) 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
3	Domestication of the Philippine native eel <i>Anguilla</i> sp.	FA Aya JAIF
4	Breeding and seed production of giant grouper (<i>Epinephelus lanceolatus</i>)	EEDJ Ayson ACIAR
5	Effects of water depth, temperature and methyl farnesoate on the mating behavior and reproductive performance of black tiger shrimp (<i>Penaeus monodon</i>) broodstock	EGE Superio

Study Title	Main Proponent	Collaborating Partners
6 Domestication of silver therapon (<i>Leiopotherapon plumbeus</i>) (Perciformes: Terapontidae): I. Nutritional evaluation of wild-sourced and hatchery-bred stocks for feed development II. Reproductive performance of wild and hatchery-bred silver therapon	FA Aya	
7 Optimization of electrolytic flocculator for paste production of important locally available microalgae in aquaculture	AV Franco	
8 Use of algal paste in the larval rearing of mangrove crab <i>Scylla serrata</i>	JJDC Huervana	
9 Utilization of artificial illumination in floating net cages on the nursery culture of Pompano <i>Trachinotus blochii</i> : effects on growth and survival of pompano and its added economic value	MIC Legazpi (JLQ Laranja)	
10 Assessment of tank-based nursery system of sandfish <i>Holothuria scabra</i>	JP Altamirano	
11 Developing transport techniques for milkfish, <i>Chanos chanos</i> , juveniles	JIL Aquino (EDJ Ayson)	
12 Economic viability of tank-based polychaete culture technology	MAE Mandario	
13 Refinement of a continuous culture system for the mass production of <i>Nanochlorum</i> sp. and <i>Brachionus rotundiformis</i>	MR de la Pena	
14 Optimizing hatchery production of early juveniles sandfish <i>Holothuria scabra</i>	JP Altamirano	
15 Verification of the effectiveness of SEAFDEC/AQD broodstock diets in improving reproductive performance in the tropical abalone, <i>Haliotis asinina</i>	JB Biñas	
16 Seed production of mangrove crab (<i>Scylla serrata</i>)	JJDC Huervana	
17 Production of <i>Kappaphycus</i> plantlets	MRJ Luhan	
18 Seed production of donkey's ear abalone, <i>Haliotis asinina</i> juveniles	RM Piloton (DD Catedral) (NC Bayona)	
Healthy and Wholesome Aquaculture		
19 Spray dried hemoglobin powder meal as an alternative protein source in grouper diets	RE Mamauag	
20 Nutritional interventions to improve reproductive performance of Indian white prawn, <i>Penaeus indicus</i> (H. Milde Edwards, 1837) (Dissertation)	SS Avanceña	DOST/UPV
21 Field testing of low cost aquaculture feed for milkfish and tilapia in ponds and cages	RE Mamauag	NFRDI
22 Evaluation of raw meal, fermented and live green macroalgae <i>Chaetomorpha linum</i> as food source for farmed <i>Penaeus monodon</i>	JB Biñas	
23 Evaluation of phytoecdysteroids crude extract from spinach in molting and growth of mangrove crabs, <i>Scylla serrata</i>	JIL Aquino	

Study Title		Main Proponent	Collaborating Partners
24	Quantitative amino acid requirements of pompano, <i>Trachinotus blochii</i> : Requirements for leucine, isoleucine and histidine	RE Mamauag (RMA Cabrera)	
25	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	
26	Efficacy of different therapeutants against <i>Caligus</i> sp. infestation in tropical fish under laboratory conditions	GE Pagador	
27	Safeguarding the future of the Seaweed Industry of the Philippines: Disease and Pest Detection (WP1)	J Faisan/ MRJ Luhan (I) AQ Hurtado/ MRJ Luhan/ J Faisan (II)	UKRI Global Challenge Research Fund (GCRF) Global Seaweed STAR
28	Production of <i>Penaeus vannamei</i> using Biofloc System with sludge removal facility (SRF) to demonstrate the productivity of old earthen ponds	EGE Superio	
29	Demonstration of grow out techniques of commercially-viable shrimp species (<i>P. monodon</i> , <i>P. vannamei</i> , <i>P. indicus</i>) using SEAFDEC/AQD formulated diet and commercial feed	RE Mamauag	
30	Hatchery production and semi-intensive pond culture of <i>Penaeus indicus</i>	EGE Superio (SS Avanceña)	
Maintaining Environmental Integrity through Responsible Aquaculture			
31	Strategic feeding of milkfish (<i>Chanos chanos</i>) for efficient marine cage culture production	PA Palma	
32	Increasing technical skills supporting community-based sea cucumber production in Vietnam and the Philippines	JP Altamirano	ACIAR
33	Comparison of oyster <i>Crassostrea iredalei</i> growth and survival in brackishwater pond and river using pouch	MJHL Ramos	
34	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
35	Grow-out culture of abalone in pipes	MJHL Ramos	
36	Polychaete culture in raceway ponds	VR Alava	
Meeting Social and Economic Challenges in Aquaculture			
37	Selecting optimal stocking density of mangrove crab (<i>Scylla serrata</i>) hatchery production in different seasons: a decision theory approach	RJG Castel	
38	Assessment of Anguillid eel nursery industry in the Philippines and selected Southeast Asian countries	MLC Aralar	JAIF

Study Title		Main Proponent	Collaborating Partners
Reinforcement and optimization of fish health management and effective dissemination in the Southeast Asian Region			
39	Enhancement of vaccine efficacy for the prevention of viral nervous necrosis in high value marine fish	RV Pakingking Jr.	GOJ-TF
40	Establishment of protective measures against persistent and emerging parasitic diseases of tropical fish	GE Pagador	GOJ-TF
41	Application of adjuvants, carriers and RNAi technology to enhance the antiviral immune response of shrimp to WSSV	EC Amar	GOJ-TF
42	Epidemiology of the early mortality syndrome (EMS) in <i>Penaeus monodon</i>	EA Tendencia	GOJ-TF
43	Technology extension and demonstration	RV Pakingking Jr.	GOJ-TF
44	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
Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources			
45	Responsible aquaculture through aquasilviculture	EA Tendencia	GOJ-TF
46	Use of plant-based protein sources in tilapia feeds for improved production traits	FA Aya (MRR Eguia)	GOJ-TF
47	Promotion of resource enhancement of seahorses	SMB Ursua	GOJ-TF
48	Community-based integrated production of abalone <i>Haliotis asinina</i> and sandfish <i>Holothuria scabra</i> through culture, sea ranching and stock enhancement	ND Salayo	GOJ-TF

SPECIAL PROJECTS

49	Demonstration and verification of sustainable and efficient aquaculture techniques by combination of multiple organisms	ND Salayo (M Kodama)	JIRCAS
50	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	Department of Science and Technology
GOJ-TF	Government of Japan - Trust Fund
JAIF	Japan-ASEAN Integration Fund
JIRCAS	Japan International Research Center for Agricultural Sciences
NFRDI	National Fisheries Research and Development Institute
UKRI	UK Research and Innovation
UPV	University of the Philippines Visayas

Five thrusts of SEAFDEC/AQD

To support the priorities of the Department's host government, SEAFDEC/AQD pursued five thrusts that are implemented in collaboration with Philippine government agencies.

Fry Sufficiency Program

Development of Cost Effective Feeds

Oplan Balik Sugpo

Joint Mission for Accelerated Nationwide
Technology Transfer II

Manpower Development



3D rendering of the multi-species hatchery in Lingig, Surigao del Sur prepared by SEAFDEC/AQD for DA-BFAR

Thrust 1 Fry Sufficiency Program

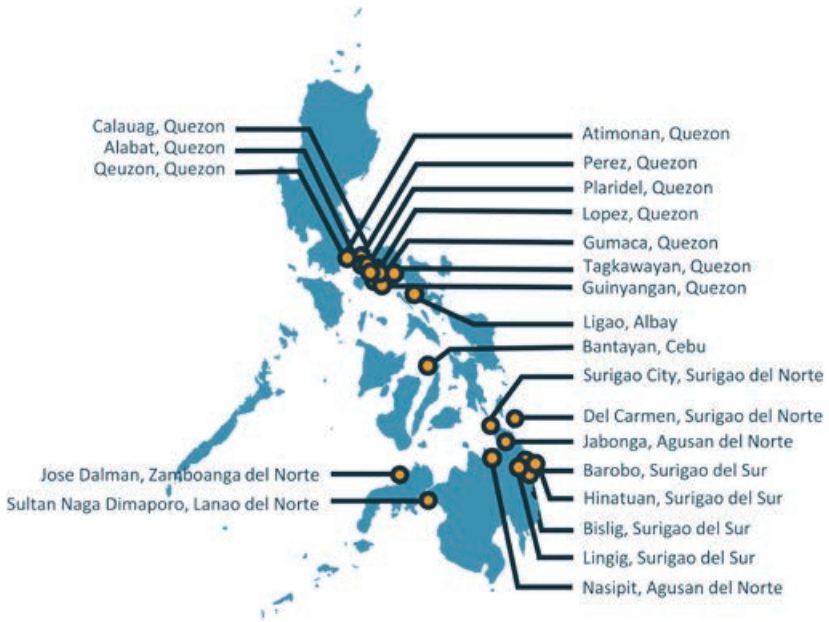
Overview

The Philippines has been highly reliant on milkfish fry imports in order to meet the large annual fry requirements of about 2.5 billion fry. The flagship program of the current SEAFDEC/AQD administration aims to address the reliance on imports by improving the quantity of milkfish fry produced locally to meet the country's demand.

In accordance with a 2018 Memorandum of Agreement (MOA) between the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) and SEAFDEC/AQD, proposed areas of multi-species hatcheries legislated during the 16th and 17th Philippine Congress were evaluated. SEAFDEC/AQD's role in the program is to provide technical assistance by performing suitability surveys of the proposed sites; to conduct field trials of low-cost feeds; to establish a feed mill in the site; and to conduct trainings for manpower development.

Once constructed, the hatcheries will serve as central and satellite milkfish hatcheries providing for the seed requirements of grow-out facilities in their respective regions. Each marine hatchery is capable of producing 25 million milkfish fry annually. Even though the facilities are designed for milkfish, they are also capable of accommodating other species.

Aside from production, the hatchery facilities will also serve as a training and demonstration facility for private groups that plan on putting up hatcheries. The facilities may also accommodate students for internship and on-the-job training. Resident technicians may provide hands-on trainings on various aspects of hatchery operations.



Sites of legislated multi-species hatcheries that were assessed by SEAFDEC/AQD



On-going construction of the multi-species hatchery in Lingig, Surigao del Sur

Site feasibility studies

In 2019, SEAFDEC/AQD evaluated new sites in Hinatuan and Surigao City in the CARAGA region as well as another site in Quezon Province. Three sets of engineering layouts and detailed feasibility studies of the sites were turned

over to the BFAR Central Office, respective BFAR Regional Offices, and local government units (LGUs). Meanwhile, detailed feasibility study reports for the following sites were submitted: Perez, Quezon (RA 10945); Sultan Naga Dimaporo, Lanao del Norte (RA 10860); and Jose Dalman, Zamboanga del Norte

(RA 10859). Six out of the 15 legislated areas listed covered in the MOA have already received engineering plans and feasibility study reports.

Construction began on the multi-species marine hatchery in Lingig, Surigao del Sur (RA 10787). It is expected to be completed around the second quarter of 2020. Meanwhile, construction of the hatchery in Del Carmen, Surigao del Norte under RA 10825 began in the last quarter of 2019. The only freshwater multi-species hatchery in Jabonga, Agusan del Sur under RA 10813 will also begin after following a bidding process.

Profiling of hatcheries

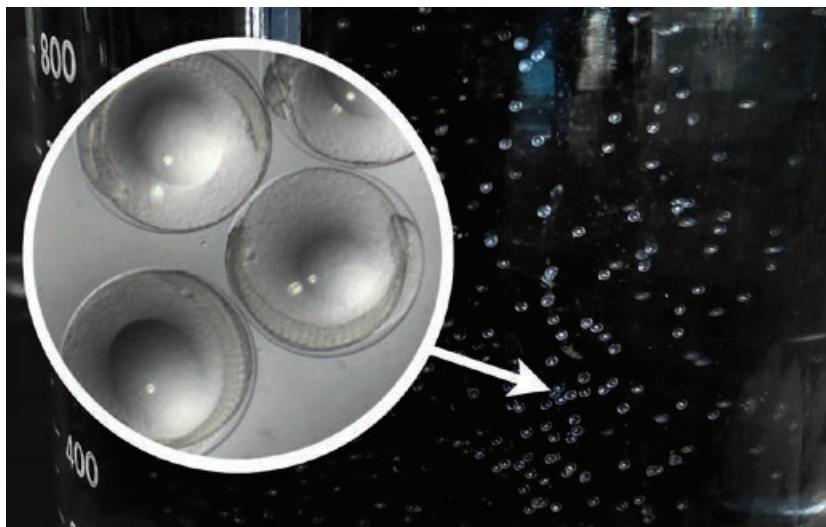
SEAFDEC/AQD extended help to BFAR-6 by providing technical assistance for the rehabilitation of non-operational, abandoned, or damaged hatcheries in the hope of increasing fry production in the province of Iloilo.

Profiling was done in the 1st district of Iloilo. Nine hatcheries in the area were found to be operational and were culturing tilapia, shrimp (*Litopenaeus vannamei* and *Penaeus monodon*), milkfish, and seabass. Meanwhile, 12 hatcheries were listed as abandoned or non-operating due to sickness or death of owner, bankruptcy, and lack of finances to continue operations.

It was also noted that most abandoned hatcheries used to culture *P. monodon*. Profiling of hatcheries was done to provide baseline information towards the rehabilitation of non-operational hatcheries in the area in order to maximize the production of milkfish fry. Recommendations, cost estimates, and other technical plans for the rehabilitation of the identified hatcheries will be drawn up and submitted to BFAR for approval.



A hatchery in Batan, Aklan which is subjected for repair and rehabilitation courtesy of SEAFDEC/AQD, BFAR-6, and the private sector



Fertilized milkfish eggs collected from spawning events induced by environmental manipulation of broodstock tanks at SEAFDEC/AQD

Environmental manipulation of milkfish breeders

To further support the Fry Sufficiency Program, SEAFDEC/AQD has undertaken the problem of limited spawning of milkfish during colder months. While milkfish mature and are ready to spawn after 5 years, the water temperature needs to be 30°C or above. The spawning season in the Philippines is usual-

ly limited from March to November when the waters are warmer.

SEAFDEC/AQD installed water heaters in a milkfish broodstock tank which raised the average temperature of the water to about 30°C as opposed to 26.1°C in the tank without heaters. There were eight spawning events that occurred during November 2019 which produced 2,200,075 eggs, 1,980,188 of which were good eggs with a hatching rate of 90%. In Decem-

ber 2019, there were five spawning events that yielded a total of 698,163 eggs and 541,000 of those were classified as good eggs with a

hatching rate of 77.49%. In November and December 2019, during a period when no production is usually experienced, SEAFDEC/AQD

was able to distribute 970,000 and 120,000 milkfish fry, respectively.

Thrust 2 Development of Cost Effective Feeds

Overview

Alternative sources of protein have been sought to replace fish meal in aquaculture feeds. The use of fishmeal in feeds has been regarded an unsustainable practice and finding suitable substitutes is seen to lessen aquaculture's impact on the environment and reduce costs, especially if alternative ingredients are locally available. Numerous studies have been undertaken to examine the effects of fish meal replacement by another source of protein such as animal by-products or plant-based protein. In collaboration with the Philippine National Fisheries Research and Development Institute (NFRDI), SEAFDEC/AQD aims to identify and utilize cost-effective feed ingredients which can be used as an alternative to fish meal. The average cost of commercial feed is between PHP 34 to 36 per kg (US\$ 0.65 to 0.71) which is higher compared to the SEAFDEC/AQD formulated diet which costs around PHP 19 to 22 per kg (US\$ 0.37 to 0.43). When produced in a commercial scale, the cost of the SEAFDEC/AQD feed could even be lower.

Milkfish in net cages

Initial growth trials for milkfish were conducted at the Igang Marine Station in floating net cages last June 2019. Milkfish juveniles with an average body weight of 33 g were stocked in six 5 x 5 x 3 m floating net cages at a stocking density of 33.4 fish per m³ (2,500 fish per cage). Two dietary treatments (SEAFDEC/AQD formulation

Project to lower cost of aquafeeds kicks off in Guimaras



Officers of SEAFDEC/AQD, NFRDI, and BFAR during the launching of the field testing project at Igang Marine Station in Guimaras

A new feed formulation that hopes to lower the cost of fish farming and make fish more affordable to small-scale growers kicked off with the field-testing of the low-cost feed at the Igang Marine Station of last 15 May 2019.

The new formulation, developed by scientist Dr. Roger Edward Mamauag, uses cheaper alternative ingredients and will also be tested around the country in partnership with the National Fisheries Research and Development Institute (NFRDI) and the Bureau of Fisheries and Aquatic Resources (BFAR).

Dr. Mamauag said that the feed cost can still go down if the feed is produced in a commercial scale. However, the positive research result still needs to be verified through field testing.

He explained that the field testing of the feed in Guimaras is for milkfish reared in sea cages. This feed will also be tested in milkfish sea cages located in La Union and Eastern Samar. He also said that there will also be a field testing of cost effective feeds for tilapia in Nueva Ecija, Lanao del Norte, and Batangas.

Moreover, according to Maria Theresa Mutia, chief aquaculturist of NFRDI, commercial adoptors will be tapped for the validation of the verification trials on the third year of this three-year project.

Drusila Esther Bayate, NFRDI interim executive director, said that she hopes the project will be a success. "I foresee it will be because of its practicality and it's really a very good technology," said Bayate.

and commercial grower feeds) were used wherein each treatment had three replicates.

After 120 days of culture, milkfish fed with the SEAFDEC/AQD diet achieved a total of 2,795 kg of harvest which is higher than that of milkfish fed with commercial feed which achieved 2,235 kg of harvest. In terms of average body weight, milkfish fed with the AQD diet gained an average of 393 g while commercial diet-fed milkfish gained an average of 325 g. As for the feeding performance, the fish consumed a total of 5,870 kg of SEAFDEC/AQD diet and 5,420 of commercial feed with a feed conversion ratio of 2.1 and 2.4, respectively.

Tilapia in ponds

In partnership with NFRDI Muñoz, a feeding experiment for tilapia was initiated at Muñoz, Nueva Ecija last 27 June 2019. Tilapia fingerlings with an average body weight of 21 g were stocked in 6,300 m² ponds at a stocking density of 5 fish per m² (1,500 fish per pond). Two dietary treatments (SEAFDEC/AQD formulation and commercial grower feeds) were used wherein each treatment had three replicates. A second feeding experiment for tilapia was conducted at Lala, Lanao del Norte on 17 September 2019. Tilapia fingerlings with an average body weight of 11 g were stocked in 6,200 m² ponds at a stocking density of 5

fish per m² (1,000 fish per pond). Two dietary treatments (SEAFDEC/AQD formulation and commercial grower feeds) were used wherein each treatment had three replicates.

After 120 days of culture, the experiments harvested a total of 1,098 kg from ponds fed with the SEAFDEC/AQD diet and 1,024 kg from ponds fed the commercial diet with an average body weight of 338 and 308, respectively. Tilapia fed with the SEAFDEC/AQD diet consumed more feed (1,633 kg) compared to those fed with commercial feeds (1,558 kg). Feed conversion ratio was 1.4 for the SEAFDEC/AQD diet and 1.5 for commercial feeds.

Thrust 3 Oplan Balik Sugpo

Overview

Production of tiger shrimp (*Penaeus monodon*) suffered a drastic decline back in the late 1990s. The Oplan Balik Sugpo program, launched in 2017, aims to revive the tiger shrimp production in the Philippines and provide farmers with good quality fry for grow-out culture.

The shrimp hatchery complex was prepared to provide high quality shrimp fry to be stocked in ponds. Enhanced biosecurity operations were implemented beginning with a spawner/broodstock facility. The facility is located outside the shrimp hatchery and serves to quarantine newly-arrived spawners and to sample spent spawners for the possible presence of pathogens. After spawning and analyses, nauplii from positive spawners are chlorinated and discarded while nauplii from negative spawners are stocked in the larval rearing facility located at the shrimp hatchery.



Biosecure quarantine facility for holding and testing new tiger shrimp spawners

The hatchery is equipped with biosecurity features to prevent or lessen the accumulation of pathogens. A disinfection building was built for hatchery staff and visitors. Visitors are not allowed to enter the facility within 48 hours after visiting other hatcheries or farms. Rap-

id sand filters, UV sterilizers, filter bags, and enclosed larval rearing facilities ensure good quality rearing water. Larval rearing tanks are divided into two modules which allows resting of the other module after a run. Rearing water is sampled twice a week while the stocked fry

are sampled at PL 5, PL 10 and PL 15 stage to make sure that they are disease-free before harvest.

The technology demonstration projects for this program was divided into two phases. The first phase began in the Dumangas Brackish-water Station with the technology demonstration runs of low or partial discharge and closed-recirculating system of shrimp farming using environment-friendly schemes at the intensive, semi-intensive,

and modified extensive levels of production. Successful technology demonstration runs will then be followed by the implementation of Phase 2. In this second phase, demonstration projects will be conducted in private commercial shrimp farms.

In July 2019, disease-free fry were stocked in DBS to begin the experimental grow-out run using environment-friendly strategies. In October 2019, over 2.8 tons of ti-

ger shrimp were harvested from a 0.5-hectare pond. After 113 days of culture, 93.3% of the 100,000 PLS survived and attained an average body weight of 30 grams.

In November 2019, another 4.4 tons of tiger shrimp, with an average body weight of 30 g, were harvested from a 0.8-hectare pond after 120 days of culture, yielding a survival rate of 89.7%. More runs will be conducted to verify the culture system in 2020.

Revival of tiger shrimp farming gets boost from PH

gov't

The Philippine Bureau of Fisheries and Aquatic Resources (BFAR) lauded the series of harvests by SEAFDEC/AQD which hauled a total of 7.2 tons of the prized tiger shrimp in October and November.

"Impressive, because this is really what I wanted to see – the performance of tiger shrimp culture," remarked BFAR-6 regional director Remia Aparri, who came to witness the harvest at the Dumangas Brackishwater Station on Nov. 13, 2019.

Aparri expressed support for the *Oplan Balik Sugpo* initiative of SEAFDEC/AQD, the banner program of Chief Dan Baliao, that aims to revive tiger shrimp farming in the Philippines which was a multi-million-dollar industry in the nineties.

"The fact that it's almost two decades that we stopped *sugpo* farming, this will provide information to fisherfolks, clients, LGUs and to BFAR so that we can now, again, culture *sugpo*," Aparri added.

The regional director also mentioned that the technology from SEAFDEC/AQD, once verified and proven effective, will be adopted by BFAR-6 to be demonstrated in their technology outreach stations in Negros and Aklan, and will be introduced to fish farmers who would wish to venture in the farming of *sugpo*.

The data on the cost and return analysis as well as the biosecurity measure requirements and the protocols of the operations will also be given attention.

Aparri requested SEAFDEC/AQD to continue with the culture of the shrimp to prove the consistency of the program especially that these will help BFAR towards achieving its goal to help the fisherfolk in their farming activities to contribute to the income of the region and the country.



BFAR-6 Dir. Remia Aparri (second from left) during the shrimp harvest in Nov 2019

Thrust 4 JMANTTP II: Joint Mission for Accelerated Nationwide Technology Transfer Program

To realize the vision of SEAF-DEC/AQD, the JMANTTP II program was designed to intensify the techno-transfer of mature aquaculture technologies to stakeholders towards accelerated fish production and export revenues from the aquaculture sector. It is hoped that these will provide additional and alternative livelihood to fisherfolks through aquaculture technologies that are sustainable, economically viable, environment-friendly, and socially equitable. This project is in collaboration with the Bureau of Fisheries and Aquatic Resources (BFAR).

Techno-caravans, field demonstrations, and hands-on training were conducted with the help of BFAR. Field evaluation of BFAR's national aquaculture centers and regional stations were done to identify appropriate technologies for demonstration. This technology



Demonstration of induced spawning of catfish in Kabacan, Cotabato, Philippines

transfer will provide fish farmers, entrepreneurs, and other end-users access to additional and alternative livelihood.

Several on-site training courses have been conducted in different regions to promote sustainable aquaculture technologies.

Course, date, venue	Commodity focus	Total participants	Participant profile
Freshwater aquaculture training course 25 - 28 February 2019 University of Southern Mindanao Kabacan, Cotabato Province	tilapia, milkfish, giant freshwater prawn, catfish	68	Fishpond owners, farmers, and operators from Region 12
Marine aquaculture of high-value species training course 20 - 22 May 2019 Tacloban City, Leyte Province	groupers, seabass, pompano	64	Training officers and fish growers from Region 8
Milkfish training course 15 - 18 October 2019 National Mariculture Center, Panabo City, Davao del Norte Province	milkfish	40	Milkfish farm operators, technicians, LGU staff, BFAR staff

Thrust 5 Manpower Development

Following one of the mandates of SEAFDEC/AQD, the program, geared towards increasing the number of fish farmers in the country, trained a batch of fisheries graduates in hatchery seed production as well as grow-out using different pond culture systems. Trainees were equipped with knowledge on the farming of shrimp, marine fish, and tilapia. Graduates of the rigorous and in-depth training are meant to be deployed to projects of SEAFDEC/AQD or be recommended to various government or non-government offices and the private business sector.

In 2018, 16 graduates from different schools in Western Visayas graduated with enhanced capabilities and broadened perspectives and experiences in shrimp and multi-species marine fish hatchery operations including cage and brackishwater pond culture operations. After three months, the graduates were assigned to different facilities. Some graduates up-started the operation of BFAR-5's multi-species hatchery in Sagnay, Camarines Sur in the Philippines. The hatchery produced and sold a total of 467,000 fry.

In 2020, there is a plan to conduct another training course to produce another batch of trainees. This time, fisheries graduates from different fisheries schools, mostly in Mindanao, Quezon, and Bicol area, are the target individuals for training and deployment in constructed legislated hatcheries.



Manpower Development graduates determining the sex of a milkfish broodstock through cannulation



Manpower Development graduate counts fry after a successful run at a newly-built milkfish hatchery at Sagnay, Camarines Sur Province

Quality seed for sustainable aquaculture

A sustainable supply of good quality seedstock is key to a successful aquaculture enterprise. Quality seeds require efficient husbandry techniques and suitable farm conditions. With the intensification of aquaculture and environmental challenges from climate change, genetic quality and culture management are equally important in ensuring a steady production.

Survival of mangrove crab (*Scylla serrata*) crablets doubled in 2019 after feeding frequency and water exchange were increased.



Broodstock development

Catfish

Broodstock development and management of the Philippine native Clariid catfishes (mainly *Clarias macrocephalus* and *Clarias batrachus*) was continued, specifically by evaluating their reproductive traits for selection and propagation of quality broodstock. Offsprings from stocks collected in 2018 from Zambales, Philippines were reared and used for stock evaluation. Initial runs used the Zambales stock since no successful spawns were obtained from the other stock from Quezon. To optimize the use of the Zambales first generation offspring (F1) stock which would be on-grown to mature sizes, some juveniles were subjected to a grow-out feeding experiment using an invasive species, black mussel (*Mytella charruana*) as feed attractant and as additional source of crude protein. The feeding experiment indicated the potential of black mussel as feed ingredient that could enhance the growth performance in native catfish. Inclusion of 10% dried black mussel in okara-based diet resulted in a specific growth rate of 1.32% per day which was better than that derived from a fish meal-based diet and okara-based diet without mussel.

Immediately thereafter, a feeding trial on the Zambales F1 stocks was conducted in lake-based cages. Results after four months showed that the catfish responded best to the basal diet (sardine fish meal, soybean meal, poultry by-product meal, wheat flour, rice bran, soybean oil, lecithin, vitamin premix, mineral premix, and vitamin C) with 0.5% black mussel additive in terms of weight gain (35.94 g) and to the SEAFDEC formulated diet in terms of survival (73.30%).



Feeding of silver therapon broodstock with diets containing dried thraustochytrid.

Silver therapon

In the domestication of silver therapon (*Leiopotherapon plumbeus*), reproductive and nutritional performance were evaluated in a tank-based feeding trial. The effect of dried thraustochytrid biomass supplementation on the reproductive performance of three-year old broodstock was examined. After 14 weeks of feeding at 2% of biomass, results suggest that supplementation of thraustochytrid biomass at 0.25% could enhance the reproductive performance of female silver therapon broodstock in terms of spawning success, gonadosomatic index, as well as fertilization and hatching rate. Meanwhile, long-term feeding using diets supplemented with dried thraustochytrid biomass resulted in slight decline in growth performance, e.g. final body weight, percent weight gain and specific growth rate (SGR) of female silver therapon broodstock. Results however, showed no significant difference between the control and thraustochytrid-supplemented groups. Higher percent-

age weight gain and SGR were noted for the male silver therapon broodstock fed the diet with 0.25% thraustochytrid biomass.

Abalone

The effectiveness of SEAFDEC/AQD-formulated broodstock diets in improving the reproductive performance and the quality of larvae in tropical abalone (*Haliotis asinina*) was evaluated, especially the two best performing diets: Diet 1 (37% protein /3,381 kcal kg⁻¹ energy) and Diet 2 (42% /3,542 kcal kg⁻¹) administered to 960 hatchery-grown breeders, to determine whether further refinements are necessary or if the diets are ready for commercial application. The results showed that, except for the mean number of spawning and female survival, the performance of female and male breeders from the different treatment groups was comparable. When some female breeders were given seaweeds as feed, the results indicated better performance in terms of frequen-

cont'd on page 18...

SEAFDEC/AQD's first patent: Scientist invents new hatchery technology to save endemic 'ayungin'



Wild silver therapon caught in Laguna de Bay (left) and the invention granted to SEAFDEC/AQD as shown in Vol. 22 No. 124 of the e-Gazette of the Intellectual Property Office of the Philippines (right).

The declining population of the silver therapon (*Leipottherapon plumbeus*), a freshwater fish in the Philippines where it is endemic, is set to get a boost after a scientist devised a new system of growing its larvae in captivity.

The hatchery technique was developed by Dr. Frolan A. Aya, a scientist of SEAFDEC/AQD, and granted a patent by the Intellectual Property Office of the Philippines (IPOP) last Oct. 17, 2019.

"Silver therapon, locally known as *ayungin*, is regarded as one of the most valuable edible native freshwater species because of its tasty flesh. Despite the declining trend in wild stocks of silver therapon, demand for this food fish species remains high. It is sold from Php 200 to Php 800 (US\$ 4 to 16) per kilo when dried and around Php 500 (US\$ 10) per kilo when fresh depending on the season and catch," said Dr. Aya.

The hatchery technology, just like other technologies developed by the Aquaculture Department (AQD) of SEAFDEC, will be for free and open to fish farmers interested to venture in silver therapon culture.

Moreover, according to Dr. Aya, the hatchery protocol he developed can support the Philippine

government's "*Balik Sigla sa Ilog at Lawa (BASIL)*" program through the production of silver therapon fry for stocking in Laguna de Bay to increase the wild population.

Information from the Philippine Statistics Authority reveal that silver therapon catch in the country had declined from 4,765 metric tons in 2002 to only 1,408 metric tons in 2018.

Dr. Aya, who heads SEAFDEC/AQD's Binangonan Freshwater Station, said that he will continue to do some refinements on the technology for seed production and rearing and later demonstrate the technology to fisherfolk. Meanwhile, a manual on the biology and hatchery rearing of the fish is also in the pipeline.

"It is also my plan to do the commercial production as well as the development of nursery and grow-out technology for this important fishery resource," he added.

The patent, which was published in Volume 22 Number 124 of IPOP's official gazette released on 20 November 2019, was made possible through the efforts of SEAFDEC/AQD's Innovation and Technology Support Office headed by Dr. Roger Edward Mamaug.

cy of spawning and survival rate than those fed the formulated feeds (Diet 1 and Diet 2). Fertilization, hatching and settling rates (10 and 20 days post-stocking) were likewise comparable in all treatments. However, settling rate after 30 days was higher in seaweed-fed abalones than those given Diet 1 but remains comparable with those given Diet 2.

Tiger shrimp

To understand the conditions that encourage and facilitate mating in tiger shrimp (*Penaeus monodon*), mating behavior was observed at different depths and temperature levels. Video clips taken to observe the behavior of the shrimps indicated that molted females were pursued by males with wild males spending more time near females than captive males. Captive females appeared to molt longer than wild females in ambient temperature, where wild and captive stocks exit the molt or shell almost at the same time. There was no significant difference in the courtship behavior among the four trial combinations (wild female x wild male, wild female x captive male, captive female x wild male, and captive female x captive male) either in the fluctuating ambient or in 27°C and 32°C temperature levels for the 1.0 m water-depth experiments. However, there was a significant difference in the courtship behavior of the shrimp among the three temperature levels in terms of the time spent by males near females, times spent by females near males and time in seconds it takes for the female to exit the molt.

Grouper

Giant grouper (*Epinephelus lanceolatus*) at SEAFDEC/AQD were observed to directly undergo male sexual maturity from juvenile



Marphysa iloiloensis reared at SEAFDEC/AQD's Polychaete Hatchery

phase, and through sex change from functional females, as diandric protogynous hermaphrodites. Furthermore, females and primary males were noted to mature at an average size of 23.5 kg and 17.5 kg body weight, respectively. In Viet Nam, females and males matured at an average 33.5 kg and 34.3 kg, respectively.

At SEAFDEC/AQD, induced ovarian development was performed on the tiger grouper (*Epinephelus fuscoguttatus*) juveniles through intramuscular injection and oral administration of recombinant FSH (follicle-stimulating hormone), which was possible only until the cortical alveolar stage, after which sex reversal would ensue. Spawning induction in giant groupers in floating net cage was undertaken following SEAFDEC/AQD protocols where slow-release gonadotropin-releasing hormone (GnRH) was implanted four days before full moon and then human chorionic gonadotropin (HCG) injection performed two days before full moon.

Feeding trials in the grouper using *Proales* sp. were conducted to improve survival during larval

rearing. The inclusion of small rotifer during the first 10 days of rearing resulted in significantly higher survival rate in orange-spotted grouper (*Epinephelus coioides*), tiger grouper, and giant grouper larvae. Two batches of giant grouper juveniles have been produced.

Development of cryopreservation protocol for grouper sperm at -80°C to prolong viability and fertilization capacity has been successfully demonstrated. Grouper sperm preservation protocol at 4°C was also developed applying optimized storage conditions (osmolality, pH, sperm to diluent ratio). Successful hybridization between the tiger and orange-spotted groupers was achieved, where the hybrids were observed to have improved growth and are most resistant to diseases. Plans to use sterile hybrids to apply surrogate technology in giant grouper production have been drawn.

Polychaete

Production of nonconventional feed ingredients for diets of broodstock has been pursued using the polychaete, or mudworm, *Marphysa iloiloensis*. This polychaete is an alternative natural food for crus-

tacean broodstock as it contains 60-70% protein. “Clean” polychaetes were cultured in tanks following biosecure measures. After spawning in broodstock tanks producing a total of 421 jelly cocoons, these were then stocked in nursery tanks for 15 days and transferred to grow-out tanks where a biomass of 331 g/m² was achieved after 4.5 months. In a 13.8 m² culture area, a total of 4.91 kg of polychaetes

were harvested. About 2.12 kg of polychaetes were supplied to SEAFDEC/AQD’s Shrimp Hatchery for feeding experiments while the remaining polychaetes were used as broodstock.

Different tank shapes were tested for the grow-out culture of polychaetes wherein survival, body weight, and biomass did not significantly differ among the different tank shapes with an area of

1.0 m² each. Considering that the availability of feeds for polychaetes could be limited by the bigger culture area, additional feeds should be provided. At a standard feeding rate of 10 g/0.20 m², 10 g feeds should be added for every additional 0.20 m² culture area. In a 1.0 m² culture tank, 50 g of fish feeds should be provided once per week.

New species of polychaete discovered at SEAFDEC/AQD

A new species of polychaete was recently identified after its eggs were collected at SEAFDEC/AQD’s Dumangas Brackishwater Station and subsequently hatched and grown in SEAFDEC/AQD’s Polychaete Hatchery in Tigbauan. Now called, *Marphysa iloiloensis*, the species was named after Iloilo, the Philippine province that is host to the facilities where the worm was collected.



During spawning, eggs of polychaetes are deposited and fertilized inside this pear-shaped gelatinous “jelly cocoon” which emerges from the sediment with a stalk attached to the burrow entrance

The collected eggs were initially encapsulated in jelly cocoons when they were collected from SEAFDEC/AQD’s fishponds. It was after hatching the eggs and growing them to

adult size that some mudworms were noted to be physiologically different from another known species. It was with the assistance of experts from the Museum and Art Gallery of Northern Territory in Australia that the specimens were confirmed to be a new species. The new species was listed in the World Register of Marine Species (WoRMS) database in September 2019.

AQD has been studying mudworms, commonly found in fishponds and coastal mangrove wetlands, for their ability to eat decomposed feed from aquaculture. They have been recorded to lower the levels of organic matter, sulfur, and iron in pond soil as well as reduce its acidity.

Mudworms are also being studied for their potential as food for crab and shrimp breeders. Several studies have shown that when used as feed, they could improve the reproductive performance of crustacean broodstock. AQD is currently developing a mass production technique for *M. iloiloensis* to lessen dependence on wild stocks and attain a disease-free and sustainable supply of mudworms for use in aquaculture.

Refinement of hatchery, nursery protocols

Eel

Nursing of the Philippine native glass eels in captivity has been sustained, while development of rearing protocols has also been continued towards formulation of diets and suitable feeding schemes for glass eels and young elvers. Identification of anguillid eels based on morphological and genetic characterization and potential pathogens in nursery eel systems was also done.

In the assessment of pre-weaning diets for glass eels, *Tubifex* sp. or bloodworm gave better results than *Artemia* nauplii and artificial diets. In terms of diet form, moist paste diet gave high glass eel survival compared to those given dry and semi-moist diets.

Stocks used for the feeding trials which came from batches of glass eels collected in 2017 and 2018, were morphologically and genetically identified. Analysis of the Aparri samples enabled the identification of 96 pcs of *Anguilla marmorata* among the stock, while four were *Anguilla luzonensis*. Samples from General Santos City which were pre-sorted as *Anguilla bicolor pacifica* based on visual examination, were confirmed to be 100% *A. bicolor pacifica* based on cytB sequence alignments. Apart from mtDNA sequence analysis, seven microsatellite primers used in anguillid species were successfully tried on the Philippine anguillid eel samples, as the protocols for cross-amplification and microsatellite analysis were optimized.

Glass eels and rearing water from the surveyed eel nursery farms were monitored for the presence of pathogens. Bacterial analysis of the water samples indicated presence of pathogens identified as ectoparasites (*Trichodina* spp.),



Elvers in a rearing tank

monogeneans (*Ichthyophthirius multifiliis*), and bacteria (*Aeromonas* spp., *Pseudomonas* spp., and *Vibrio* spp.). Risk factors were noted and prevention, control and treatment measures have been recommended.

Mangrove crab

In the hatchery rearing of mangrove crab (*Scylla serrata*) seedstock, live algae and *Tetraselmis*-based algal paste were evaluated as sources of natural food for rotifers. Generally, live *Nanochlorum* best supports rotifers, however, mass production of this algae requires plenty of tanks and is prone to collapse during rainy season. Alternative sources were thus evaluated to ensure a steady supply of natural food for rotifers.

Results showed that the SEAFDEC/AQD *Tetraselmis* paste gave better results in terms of rotifers produced compared to live and commercially available *Tetraselmis* paste. On the second and fourth days of culture, the *Tetraselmis*-based algal paste produced by AQD gave significantly

higher counts of rotifers than the live and the commercially available paste. Moreover, when the growth and survival of mangrove crab larvae were assessed, no differences in growth were noted while the lowest survival was observed in the crab larvae fed with rotifers that thrived on live *Tetraselmis*. However, the survival of crab larvae from all treatments was not significantly different, suggesting that the *Tetraselmis* paste could be a good alternative to live algae.

Sandfish

To optimize the protocol for hatchery production of early juvenile sandfish (*Holothuria scabra*), new broodstock acquired from Concepcion in Iloilo, Sagay in Negros Occidental, and San Lorenzo and Igang in Guimaras, were used. From February to September 2019, 16 spawning episodes were recorded which met the target production of 20,000 early juveniles per batch. Two spawning episodes in February 2019 gave 20,000 and 23,000 juveniles respectively while a June spawning batch resulted in 51,000

juveniles. However, low survival from other spawning batches were attributed to occasional fluctuating temperature, lack of larval food, and low salinity.

In monitoring the apparent survival of larvae and settled juveniles, high mortality was found to occur during the first days of culture after the settlement plates are introduced in the tanks. Survival can be as high as 80% before the settlement plate introduction, but this is reduced to <12% after 7-10 days. Therefore, further research should focus on this critical phase to improve the overall survival.

Tank-based nursery system for sandfish was also carried out to determine the optimal rearing conditions for primary nursery system (for early juvenile sandfish) and the rearing performance in the secondary nursery system (for late juvenile sandfish). Survival of sandfish juveniles was 56% while growing at 0.02 g/day after one month of rearing in floating hapa nets in tanks with 250 sandfish/hapa initial stocking density. For the second nursery phase, adoption of supplemental feeding was done using three feed types. Results after 30 days showed that sandfish

fed milkfish fry feed achieved the highest growth rate at 0.10 g/day followed by shrimp postlarvae feed at 0.05 g/day. Sandfish fed Sargassum powder showed negative growth at -0.02 g/day.

Pompano

For the nursery culture of the snub-nose pompano (*Trachinotus blochii*), the effect of artificial light on zooplankton abundance in the water as well as its effects on the growth and survival of the fish under different feeding regimes was investigated. A first trial showed that artificial light at night significantly improved the growth of pompano fry fed 100% of the total feeding rate. Pompano that received partial feeding ration along with illumination grew less, as did pompano that received 100% of the feeding rate with no lighting. A second trial mirrored the results with mean body and total lengths still higher in fish fed 100% feeding ration with artificial light. However, an additional treatment fed 75% of the total feeding rate showed comparable result in terms of growth of fish in the control group but is more cost-effective.

Ingested zooplankton was highest during 7-14 days of culture but decreased thereafter. Pompano in lighted cages have high feeding incidence (86-100%) than those in unlighted cages (0-40%). Higher abundance of prey was observed in lighted cages compared with the control. Ninety percent of the total prey organisms in both lighted and unlighted cages were copepods.

Milkfish

The protocol for transporting milkfish (*Chanos chanos*) juveniles from the nursery to sea cage facilities was established by defining the optimal temperature and salinity requirements for the transport of milkfish juveniles, as well as the suitable conditioning period of confinement in cages in ponds before the juveniles are transported to milkfish sea cage farming sites. Results showed that milkfish juveniles (5-7 inches) can be transported for up to 12 hours in a closed system under various salinities, temperatures and their combinations, with minimal mortalities. Conditioning period of confinement prior to juvenile transport was best at 4 weeks and the least favorable result was for those conditioned for only 1 day. As for the effect of 2 phenoxy-ethanol (PE) as sedative during juvenile transport, survival of the juveniles did not differ among the treatments while survival was comparable in treatments that have 2 fish/L, 4 fish/L, 4 fish/L plus 50 ppm of PE, and that of 6 fish/L plus 50 ppm of PE.

Seaweeds

In the production of *Kappaphycus* propagules in land-based nursery laboratory and sea-based nursery cages, the target production of 44 batches of seaweed propagules was achieved in 2019. These propagules were test planted in Pedada,



Pompano nursery harvest after 105 days of culture in first trial using four treatments

Ajuy in Iloilo. Results showed that the plantlets achieved 8.7% growth rate per day. Clones of *Kappaphycus alvarezii* were also planted in Isabela City in Basilan and *Kappaphycus striatus* in Panobolon Island in Guimaras to determine the quality of carrageenan from *Kappaphycus* grown using tissue-cultured seedlings. Carrageenan yield and gel strength in *K. striatus* were significantly higher than that in *K. alvarezii*. In the case of *K. alvarezii*, the growth of the tissue-cultured seedlings was also higher compared with the farmed-sourced seedlings in grow-out.

Continuous evaluation of the tissue cultured seedlings was conducted. Carrageenan quality of the plantlets was determined by exposing tissue-cultured *K. alvarezii* to different salinity (0, 5, 10, 15, 20, 25, 30, 35, and 40 ppt) and pH levels (pH 3, 4, 5, 6, 7, 8, and 9) for 7 days. Results showed variations in the carrageenan yield, viscosity, and gel strength of the thallus exposed to different salinities and pH, but the carrageenan yield was highest in the thallus that was exposed to freshwater for 24 hours. Due to continuous optimization of nursery rearing, survival rate in the sea-based nursery cages was almost 50% which is higher than the 30% in the previous year.

Natural food

Algal paste was produced through electrolytic flocculation using important, locally-available microalgal strains. Preliminary culture and scale-up of algae production were done for the diatom *Chaetoceros calcitrans*, where the growth curve showed a logarithmic phase from day 1 to 6 which then stabilized until day 9. The results suggest that *C. calcitrans* can be mass produced in 2-4 days and used for algal paste production.



Test-planting of laboratory-produced *Kappaphycus* propagules in Pedada, Ajuy in Iloilo, Philippines



Electrolytic flocculator fabricated to produce algal paste

Upon assessment of the algal paste for its viability, length of storage, and for presence of metal residue, lead content was notably reduced by 97% (from 1,318 ppm to 43.7 ppm) through manipulation of flocculator settings including voltage, anode, and cathode units. In feeding trials, lead content of brine shrimp (*Artemia salina*) fed rice bran with *C. calcitrans* paste was significantly reduced by 78% to 7.8 ppm, compared to the lead content of *C. calcitrans* paste (34.27 ppm).

Storage after two weeks showed re-suspension capacity for both pastes stored in an air-conditioned room and in a chiller. The lag phase for paste stored in freezer was extended to four days. However, paste stored in the chiller and freezer after 1 to 3 months achieved higher densities compared to those stored in the air-conditioned room despite the extended lag phase, indicating the potential of algal paste produced by electrolytic flocculation and stored for as long as 3 months,

to be used as starter. A modified continuous culture system was developed to efficiently mass produce *Nanochlorum* sp. that would eliminate the tedious scaling-up of algal culture and reduce the number of culture tanks. In a first run that exposed *Nanochlorum* sp. to different pH levels, the highest cell density at logarithmic phase was attained at pH 8.5, but was not significantly different from other treatments.

In a second trial, significantly high cell density ($1,023.9 \times 10^4$ cells/ml) at pH 8.0 was recorded and significantly low cell density (661.2×10^4 cells/ml) at pH 6.0.

To optimize the cost of culturing *Nanochlorum* sp., four culture media (Conwy, TMRL, Yashima & Commercial II) were tested with the culture maintained at pH 8.0. The results showed significantly high cell density of *Nanochlorum*

sp. when cultured with Conwy medium (183.1×10^4 cells/ml) but was not significantly different from cultures enriched with TMRL medium (162.4×10^4 cells/ml).

Copepods

For sustainable production of harpacticoid copepods as live food for marine fish and crustacean larvae, the life cycle of the harpacticoid *Tigriopus* sp. was investigated to determine optimal conditions for mass production. In 2019, the life cycle was monitored in culture tanks without aeration and determined to take about 6 to 7 days. During mating, male *Tigriopus* sp. attaches its antennae to the posterior region of the female. An ovigerous female can produce two pairs of egg sacs after a single mating. Each pair of egg sacs has 6 to 9 clutches (containing eggs) attached to the female body for 3 days where embryonic development takes place. The egg sacs detach from the body and naupliar larval stage develops within 24 hours. After another 24 hours, the nauplii develop into copepodites. A new pair of egg sacs is immediately observed 24 hours after the first pair of egg sacs detaches from the female body.

The copepod used in this study was identified as *Tigriopus* sp. based only on morphological features, but DNA barcoding would still be necessary to confirm the species identification.

Abalone

In the large-scale seed production of donkey's ear abalone (*Haliotis asinina*), focus was made in increasing juvenile yield to 5% by feeding the appropriate diatom strain, supplementation with microparticulate diet, and application of anesthetics for early harvest of juveniles. The effect of seaweed quality on broodstock and larval



Morphology and development of *Tigriopus* sp.: (A) Adult male clasping an adult female using its antennae (mate-guarding behavior); (B) ovigerous female; (C) egg sac; (D) egg sacs to detach from the female; (E) nauplius stage; (F) copepodite stage



Settlement plates in tanks for abalone production at the SEAFDEC/AQD hatchery



performance was also evaluated while large-scale production of abalone using refined AQD methods was demonstrated. Improvement in target yield by 5% was achieved through increased diatom feeding. A total of 3,795,250 trocophore larvae were produced, out of which 47% (1,796,300 larvae) developed into veliger stage. The hatchery also produced a total of 61,137 early juveniles with 3-8 mm shell length.

Mangrove crab

In the seed production of mangrove crab (*Scylla serrata*), 7.3 million newly-hatched larvae were produced which generated 656,200 pieces of crablets, of which 581,040 were sold to stakeholders. Average survival from zoea 1 to crab instar continued to increase where the highest survival rate of 10% was attained. The increased survival was attributed to the following interventions in the hatchery protocol: reduced frequency of antibiotic application (from every 2 days to every 4 days), increased feeding frequency starting the megalopa stage (from 2 to 4 times a day), and frequent water exchange (from every 5 days to 4 days). Similarly, additional shelters were provided in the megalopa stage to reduce cannibalism.

Simple techniques double crablet survival

Simple tweaks in protocols at the SEAFDEC/AQD mangrove crab (*Scylla serrata*) hatchery have led to a significant boost in crablet survival which has increased twofold. By feeding crabs more frequently and providing cleaner water in the tanks, average survival rate from zoea (newly-hatched larvae) stage to crablet increased from an average of one percent in 2017 to two percent in 2019.

Mangrove crabs produce an average of 3 million larvae, so a one percent increase means an additional 30,000 crablets per spawner. In 2019, survival reached a maximum of 10 percent which contributed to the hatchery's production of over 650,000 pieces of crablets for the year.

Feeding frequency was increased from four to six times a day with an interval of four hours, based on the crabs' biomass at 100 percent feeding rate. The intervention worked because cannibalism among the crabs is more prominent starting in the megalopa stage (intermediate larval phase), therefore increasing the available feeds, together with providing additional shelters in the larval tanks, increased the survival.

As for the water replacement, the interval was shortened from five to four days. Siphoning of tank bottom to remove dead larvae, microalgae, and feeds is done every three days to further improve water quality.



Workers harvest crablets at the SEAFDEC/AQD mangrove crab hatchery

Healthy and wholesome aquaculture

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



Penaeus vannamei culture in earthen-pond biofloc system at the Dumangas Brackishwater Station

Overview

Innovations in fish health management and breakthroughs in feed nutrition are the approaches that could improve and sustain aquaculture production to withstand the emergence of aquatic animal diseases. Practicing healthy and wholesome aquaculture is an integral part of the solution to the threats and challenges posed by

ecological, economic, and climatic changes happening in the world. In this regard, AQD continued to undertake projects on fish health, and nutrition and feed. Fish health projects concentrate on disease diagnosis, control, monitoring and surveillance of aquaculture commodities (e.g. tilapia, pompano, whiteleg shrimp, seaweeds) as

well as on environmental integrity, certification, and food safety. Nutrition and feed projects focus on addressing the concerns and need areas in sustaining the production of aquaculture products in the region (e.g. pompano, tiger shrimp, Indian white prawn).

Fish health management

Tilapia

The effects of environmental conditions on the proliferation and virulence of tilapia lake virus (TiLV) in tilapia and its natural environment had been elucidated. The 2,050 samples collected in May to December 2019 from the top tilapia (*Oreochromis niloticus*) producing areas in the Philippines, namely: Laguna de Bay, Taal Lake, Calauan, Laguna, and Pampanga, consisted of cultured (fry, juvenile, and adult) and wild tilapia. Four weeks prior to sample collection, high mortalities were observed in floating cages at Taal Lake in Talisay, Batangas Province.

From eleven diseased tilapia collected, the clinical signs included bilateral exophthalmia, hemorrhages, bloated abdomen, enlarged spleen, pale liver, degraded brain, and scale loss. Pathological changes were also observed, such as vacuolization of the brain, hemorrhages, and blood congestion among others. In one of the samples, a dual infection of *Streptococcus* spp. and TiLV was observed. However, no syncytial hepatitis or giant nucleated cells was observed in the sample which is the major clinical signs of TiLV infection in fish in terms of histopathology.



Tilapia sampled from a fish cage in Taal Lake in Talisay, Batangas showed pale liver and enlarged spleen, with dual infection of *Streptococcus* spp. and tilapia lake virus

Pompano

In evaluating the efficacy and determining the effective dose of different chemotherapeutants (emamectin benzoate, hydrogen peroxide, and onion) against pre-adult and adult sea lice (*Caligus* sp.) in pompano under laboratory conditions, an experimental run was done to test the toxicity of hydrogen peroxide on snubnose pompano (*Trachinotus blochii*). Results showed that the LC_{50} values were

3019.95, 3019.95, 1772.48 and 1363.69 ppm for 24, 48, 72 and 96 h, respectively. In vitro sensitivity test of *Caligus* sp. using different concentration of emamectin benzoate (EMB) was conducted. Preliminary results showed that effective concentration (EC_{50}) was 0.4 ppm. Based on such results, the protocol for preventive treatment against the sea lice would be established.

Whiteleg shrimp

On the production of whiteleg shrimp (*Penaeus vannamei*) using biofloc system, a sludge removal facility was tested to demonstrate the productivity of old earthen ponds during the wet season. *P. vannamei* were cultured in two ponds, fed commercial pellets and given commercial probiotics during water culture and during actual culture. At 81 days of culture, the average body weight was 12.18 g and survival rate was 91.15%. Regular disease monitoring, including bacterial, AHPND and WSSV analysis, was done to ensure that shrimp stocks were disease-free.



After feeding, sludge material is pumped out of *Penaeus vannamei* biofloc ponds through a sludge removal facility

Seaweeds

In safeguarding seaweeds from pests and diseases, initial molecular identification of epiphytes was conducted to develop detection protocols and diagnostic tools for controlling seaweed diseases and pests. While the protocol needs further optimization, sampling was conducted in the Provinces of Palawan (Honda Bay in Puerto Princesa City and municipalities of Balabac, Quezon, and Taytay) and Zamboanga (Layag-layag, Tigtabon, and Arena Blanco) in the Philippines. The occurrence of ice-ice and endophytes were assessed on-site.

The results indicated the presence of ice-ice and epiphytic filamentous algae (EFA) ranging from 0-10% and 0-11.2%, respectively, for the eight farms visited. Interestingly, *Sargassum* sp. was observed at higher degree of occurrences with 33.3% and 46.5% in Pamantolon and Pularaquen (in Taytay, Palawan) respectively. The macro-epiphyte, *Ulva reticulata*, and other red epiphytes were observed in the farms in Zamboanga. These results suggest that there is widespread occurrence of ice-ice and epiphytic pests in these farming regions, albeit in varying degree of infection

and infestation rates, reflecting the current declining production in the country. Collected seaweed samples with epiphytes will be further analyzed through histology, electron microscopy and molecular processes for identification.

Farming of *Kappaphycus striatus* (sacol) was conducted in an identified sentinel farm in San Dionisio, Iloilo, Philippines, where the farm's environmental parameters and results of monthly seaweed biomass sampling are being monitored and recorded.

Nutrition and feed projects

Pompano

Pompano. The essential amino acid requirements of pompano for leucine, isoleucine, and histidine were determined to develop a cost-effective feed for the species. Test diets have been formulated to contain different levels of histidine, and tested in pompano for 70 days. Results showed that the

dietary requirement of pompano for histidine is 1.61%. The first run for the leucine and isoleucine requirements were also undertaken. Results showed that the amino acid requirements were around 2.8 g leucine and 1.4 g isoleucine per 100 g diet. However, most of the deficiency signs such as open gill operculum, cataract, and eroded

fin were observed at these values. A second run will be carried out to verify the results.

To test whether spray-dried hemoglobin powder meal could be a good source of protein for growth of marine fishes, spray-dried hemoglobin meal was given to pompano maintained in net cages at the Igang Marine Station. The

hemoglobin powder meal, which was sourced from porcine and processed using a spray drying technique, contains 92% crude protein and has a 99% protein digestibility. The results indicated that the dietary levels of dried hemoglobin meal ranged from 3% to 27%. While the experiment is ongoing, the RNA expression of the liver and intestine will be analyzed as an effect of the different levels of hemoglobin meal in the treatment diet.

Tiger shrimp

The utilization of unfermented, fermented, and live green microalgae *Chaetomorpha linum* as food source for the tiger shrimp (*Penaeus monodon*) was evaluated. *Chaetomorpha* seaweed, with known potential benefit in cultured shrimps and other farmed aquatic species, was used as food source and given either through its inclusion in formulated feeds or by direct feeding through a co-culture system. Since the algae, with about 15% crude protein, could be used as feed ingredient after fermentation to enhance the levels of nutrients, the fermentation protocol was optimized.

Partial counts indicated that although the highest total number of particles (TNP) at 1.83×10^8 particles/ml was produced using an enzyme concentration of 750 μL per 100 ml base material and incubation period of 60 minutes, lower concentrations proved to be effective as well. Results of the experiments on survival and growth of tiger shrimp given feed containing unfermented *Chaetomorpha* meal indicated that inclusion of up to 10% does not adversely affect shrimp growth. While the apparent nutrient digestibility experiment of the algae in shrimp is currently



Penaeus indicus harvested from ponds at the Dumangas Brackishwater Station

on-going, the results will be compared to control diet and two other reference diets. From the results, the efficacy of unfermented *Chaetomorpha* meal for other species (e.g. tilapia and milkfish) would also be evaluated after its incorporation in the fish diets.

Indian white shrimp

On the production of the Indian white shrimp (*Penaeus indicus*), its growth was monitored when given the *P. indicus* feeds (40.0% crude protein) and low-cost tilapia feeds (33.7% crude protein) to compare and demonstrate the profitability of semi-intensive pond culture of *P. indicus*. Stocking of PL20 was done in four ponds with biosecurity measures and harvested after a 90-day culture period. Results showed that the percent survival of shrimps fed the tilapia diet was 69.9% and 70.0%, while shrimp fed shrimp formulated diet was 75.1% and 81.8%. The growth rates of shrimps given the two feeds were comparable. However, the cost of tilapia feeds is cheaper than that of the *P. indicus* feeds, making the

former a more cost-effective option.

The optimal dietary protein to lipid ratio that would improve the reproductive performance of *P. indicus* was also determined. Breeders were fed test diets with different ratios of protein and lipid (35:6, 35:12, 35:18, 45:6, 45:12, 45:18, 55:6, 55:12 and 55:18) and a control diet (fresh frozen marine diet consisted of mussel, squid and polychaete) for 30 days.

Gonadal development was monitored using a digital caliper that measures the ovary shadow of test animals. Highest maturation response was on test diet 55:12, followed by both the control diet and test diet 45:18. A significant interaction between protein and lipid ($p=0.01$) was noted and regardless of protein level, breeders fed test diets with 6% lipid have poor gonadal maturation. Results suggest that a well formulated artificial diet that satisfies the protein and lipid requirements can support successful gonadal development without fresh diet supplementation in *P. indicus*.

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.



Student interns help monitor sandfish stocks in floating hapa nets at the Igang Marine Station of SEAFDEC/AQD in Guimaras, Philippines

Milkfish

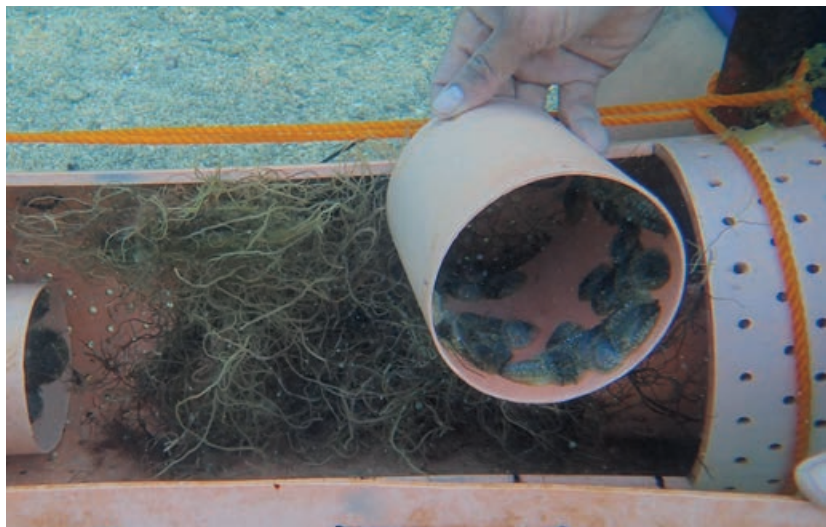
In the development of an efficient feeding technique for milkfish (*Chanos chanos*) in marine cage grow-out culture, physiological studies were undertaken to understand the compensatory growth response of milkfish. Starvation trials in milkfish fingerlings (~20 g) and juveniles (~100 g) have shown that compensatory growth response is primed after two to four days of starvation wherein liver energy reserve (hepatosomatic index) is reduced to minimum levels associated with increased circulating levels of cortisol. Subsequent studies will look into the recovery of normal physiology and lost growth during period of refeeding in fingerlings and juveniles. Phenotypic observations will be verified through genetic analyses utilizing the milkfish transcriptomic data (brain, pituitary gland, gut and liver) that has been already established. A feeding schedule consisting of cycles of starvation and refeeding will then be established and tested for milkfish grow-out culture in marine cages.

Oysters

Growth and survival of oysters (*Crassostrea iredalei*) cultured in brackishwater ponds were assessed and compared with production in a nearby river in Panay, Province of Capiz. This is a follow-up to the recently concluded study funded by the Department of Science and Technology-Philippine Council for Agriculture, Aquatic, and Natural Resources (DOST-PCAARRD) which identified the 'pouch method' as the best strategy in producing single oysters with fast growth and homogenous sizes. The experiment using rafts and pouches commenced using a total of 3,000 oyster spat. After three months, higher



A sample of oyster *Crassostrea iredalei* harvested from pouch culture in experimental sites in Panay, Province of Capiz in the Philippines



Abalone in PVC pipes stocked in Sicogon Island in the Province of Iloilo, Philippines

survival was observed in oysters reared in the river set-up (86%) compared with those inside the ponds (32%). Mortality in ponds was due to predation by crabs. After five months of culture, mean length and weight were higher in oysters reared in the river (8 cm and 66 g) than those in ponds (7 cm and 43 g) which could be associated with water conditions. Higher temperature, salinity, sulfide and nitrite were recorded in the ponds

than in the river, although the river also registered higher nitrate, phosphate and ammonia.

Abalone

An alternative culture method is being developed for donkey's ear abalone (*Haliotis asinina*) using PVC pipes as culture container and seaweed (*Gracilariopsis heteroclada*) as natural food. The project is a collaborative effort with Ayala Corporation, as part of the industry

collaboration initiative which targets local island-based communities as beneficiaries.

The alternative culture system makes use of perforated PVC pipes, previously shown to promote good growth and survival of abalone, which are practical and easy to deploy. In earlier culture trials, stocking of about 6,000 abalone juveniles at Sicogon Island in northern Iloilo, Philippines led to successful partial harvest of abalone after 3 months of culture. In October 2019, a total partial harvest of about 1,500 abalone was recorded. The project would be turned over to the private partner and local communities as part of SEAFDEC/AQD's commitment to disseminate developed aquaculture technologies.

Sea cucumber

SEAFDEC/AQD has been at the forefront of developing technologies for the culture of the tropical sea cucumber (*Holothuria scabra*) or sandfish, in collaboration with the Australian Centre for International Agricultural Research (ACIAR) and various research partners in the Philippines. In the first year of the five-year project, a study was conducted to optimize hatchery production by utilizing micro-algal concentrates in lieu of live feed. Initial trials showed promising results using two commercially available micro-algae products, although confirmatory trials are still ongoing. Nursery rearing are focused on sea-based floating hapa nets because this is the most apt and practical method for the Philippines, based on previous studies. Secondary nursery culture in pens showed fast growth of sandfish, although it was found that predation was a major challenge in the culture of sandfish in the field. Studies on predation



Fast-growing sandfish sampled from nursery pens at Igang Marine Station



Raceway culture experiment system for polychaetes using hapa nets

mitigation measures will also be explored.

Polychaetes

Marine worms or polychaetes, which are used as an additive in maturation feeds to enhance the reproductive performance of crustacean and fish broodstock, are also known to be good potential bioremediators of muddy sediments. Enhancement of the culture methods for polychaetes (*Marphysa* sp.) is being explored. Production of poly-

chaetes in controlled environments is being developed to ensure the products are disease-free. Results of a stocking density experiment in land-based raceways using hapa nets showed that as much as 2,000 polychaetes could be stocked per square meter. In a culture duration of only four months, the biomass yield could be over 100 g/m². In the same period, soil organic matter content could be reduced from >5% to 3.8%, confirming the bioremediation potential of the species.

Environment-friendly tiger shrimp farming pushed

With its premium flavor and superior economic value, tiger shrimp is being pushed as an alternative species to farm alongside the popular whiteleg shrimp or *vannamei*. Tiger shrimp's potentials were underlined by SEAFDEC/AQD Chief Dan Baliao during the 12th Philippine Shrimp Congress held in Bacolod City.

"Tiger shrimp has good attributes of its own like better taste and better price compared to *vannamei*," said Baliao during the opening of the congress on Nov. 20, 2019.

Baliao said shrimp farming in the Philippines was a multi-million-dollar industry in the 90s with the country ranking among the top 10 shrimp-producing countries in the world with a production of about 40,000 tons per year.

"However, the industry was ill-prepared for intensification. There were no guidelines to support the rapid expansion of the shrimp industry," he added.

The use of unapproved chemicals and release of untreated wastewater into the environment was rampant then, triggering a series of different diseases that plague the industry until now.

Environment-friendly schemes

"We have learned our lessons. Even before the year 2000, we have started to advocate environment-friendly shrimp aquaculture of tiger shrimp," said Baliao.

"We encourage the farming of other shrimp species, especially tiger shrimp in polyculture with finfish species to cater to farmers who prefer to farm extensively, or in monoculture using the semi-intensive method."

The SEAFDEC/AQD culture method uses green water technology that stabilizes water quality and naturally suppresses the harmful luminous and other *Vibrio* bacteria that cause massive mortality in shrimp. This is achieved by stocking tilapia and milkfish in the same water where shrimp are grown.

"Mucus secretions of tilapia and milkfish cultured in the corners and center of the pond create green water that suppresses luminous bacteria count," the Chief said.

The fish are contained inside sludge collectors at the center and corners of the pond which serve to collect waste that otherwise deteriorate the quality of the water. Meanwhile, water discharged from shrimp ponds are first treated by a series of baffles (that help settle suspended particles) and bioremediators such as seaweed and the filter-feeding oysters and mussels.

"These methods are socially equitable and more environmentally sound which improves the sustainability of shrimp farming," added Baliao.



The different components of environment-friendly shrimp farming by SEAFDEC/AQD is illustrated in a diorama at the 12th Philippine Shrimp Congress in Bacolod City.

Adapting to climate change

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



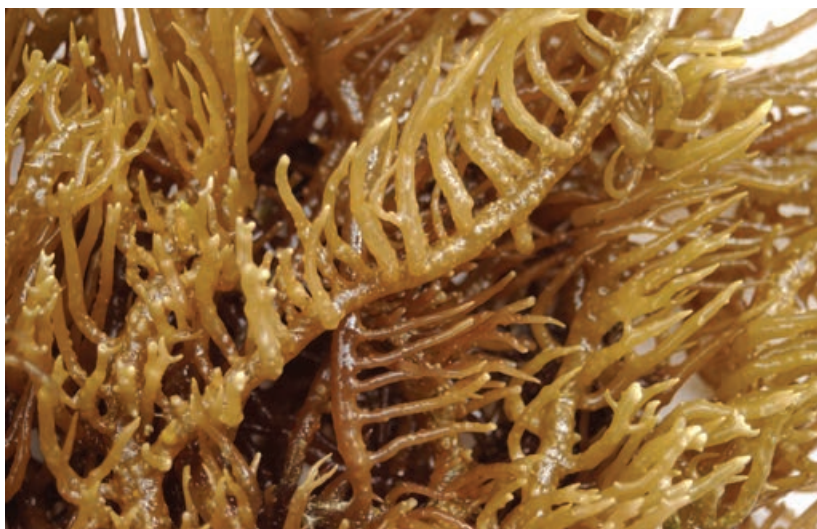
Coastal communities, such as this in Molocaboc Island in the Philippines, are among the most vulnerable to climate change.

Addressing impacts of climate change

Extreme weather disturbances such as more frequent and stronger typhoons, long dry spells resulting to droughts, and frequent heavy rains resulting to severe flooding are some of the phenomena that have been recently linked to climate change. These changes are projected to impact broadly across ecosystems and economies, increasing pressures on all livelihoods and food supply chains, including in aquaculture. The future food supply will be a central issue as resources come under greater pressure.

Climate change is a compound threat to the sustainability of aquaculture development. Impacts occur as a result of gradual warming, the increasing acidity of the oceans and associated physical and chemical changes as well as from frequency, intensity and location of extreme climatic events. How these changes affect the aquaculture organisms in general, the different aquaculture systems and structures, the various support systems to aquaculture operations, and the vulnerable fish farmers in the region need to be assessed and corresponding adaptation measures formulated.

Aside from the inclusion of climate change topics in aquaculture training courses, several activities under SEAFDEC/AQD's Departmental Programs investigate the impact of environmental variations to aquaculture organisms. The effects of temperature and salinity on the reproduction of copepods that are potential food during fish and crustacean seed production was investigated as well as the effects of salinity and pH on growth of seaweeds and growth of green algae used in rotifer culture. The effects of water temperature on the mating



The effect of different salinity and pH levels on the carageenan quality of the seaweed *Kappaphycus alvarezii* was studied.

performance of captive and wild shrimp broodstock was studied as well as the effect of abrupt salinity fluctuations on the early recruitment of sandfish.

The past and current activities on the evaluation of potential feed ingredients from various sources (e.g. industrial, agricultural and fish processing by-products) as replacement for fish meal and fish oil help address constraints of diminishing supplies of fish meal and fish oil in light of the expected impacts of climate change on global fishery resources. For example, based on previous work on alternative ingredients, a low-fish meal feed (1-2% fish meal) for tilapia and milkfish is now being field tested, and the information on nutrient profiles of these ingredients could be added into the Regional Feed Ingredients Database. These initiatives contribute to the overall resilience of the aquaculture sector in the region.

Ongoing studies on persistent and emerging diseases (white spot syndrome, acute hepatopancreatic necrosis diseases, enterocytozoon hepatopenaei, nervous necrosis

virus, tilapia lake virus, as well as other viral, bacterial, and parasitic diseases) and the development of measures to prevent and control disease outbreaks (e.g. vaccination, immunostimulation, green-water culture) likewise address climate change issues. Formulation of policy recommendations as well as development of guidelines for the establishment of an early warning and response system for disease outbreaks based on the outcomes of Regional Technical Consultation on the said issue help improve capacity in dealing with disease outbreaks in the region. This system could be linked to other initiatives like the warning system for harmful algal blooms or fish kills, and contribute further to building resilience to the impacts of climate change.

Current initiatives in promoting community-based resource enhancement and aquaculture-based community livelihood programs also improve the resilience of coastal communities, one of the most affected sectors of society, to the impacts of climate change.

Meeting social & economic challenges

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



Milkfish being harvested from the community-based Integrated Multi-Trophic Aquaculture setup in Barangay Pandaraonan in Guimaras, Philippines

Integrated multi-trophic aquaculture

The socioeconomics component of the Integrated Multi-Trophic Aquaculture (IMTA) project, which was implemented from 2014 to 2019 in collaboration with the Japan International Research Center for Agricultural Sciences (JIRCAS), was aimed at developing technologies for sustainable aquatic production in harmony with a tropical system. The role of aquaculture in addressing poverty in the fisheries sector has been elucidated given the economic and social challenges experienced in the implementation of IMTA of milkfish (*Chanos chanos*), sandfish (*Holothuria scabra*), and seaweeds (*Kappaphycus* sp). The seven IMTA production runs had been co-managed by local fisherfolks, women, and local government in Barangay Pandaraonan in the municipality of Nueva Valencia in Guimaras Province. The biophysical and socioeconomics data collected from these seven runs provided basis for evaluating the IMTA results during summer and rainy seasons.

The last run of the IMTA of milkfish indicated that of the 5,000 juveniles stocked, 92.8% or 1.25 metric tons were harvested, 0.8% died and 6.4% were uncounted. Profitability was primarily constrained by a combination of factors that include high production cost due to total cost of feeds used that comprise 64% of the variable cost. While the cost of fingerling accounted for 16% of the variable cost, the unrecovered proportion of stocks due to probable poaching, escapees, and unrecorded mortalities also dented the profitability. Re-investments in terms of replacement of depreciated bamboo poles in the pen likewise increased the fixed cost.

The harvest of co-cultured sandfish and seaweeds also needs improvement because the high-value co-culture species are supposed to overcome the impact of increasing production cost, aside from mitigating the impact of organic matter. Nonetheless, monitoring of environmental parameters such as organic matter and other pollutants did not indicate significant deterioration in the low-density open culture system. Community-based strategies to overcome economic losses need further study in order that the application of IMTA would benefit the potential adopters of this technology.

In view of these social challenges in community-based implementation of the IMTA of milkfish, characterization and levels of improvement of sustainable livelihood assets had been determined. This was done through an interview of 52 stakeholders for an inter-temporal analysis of sustainable livelihood assets (SLA) relevant to the implementation of community-managed IMTA. Using inter-temporal Likert-scale rating, the analysis showed improvement in four out of five categories of livelihood assets such as human, environmental, financial, and social assets associated with this IMTA project. In contrast, physical livelihood assets (such as pens, cages, fish value-adding equipment) did not significantly improve as perceived by the fisherfolk stakeholders, which could be due to limited mariculture pens used that could only accommodate a few of the many fisherfolk stakeholders. The utility of the physical livelihood assets was dissipated and thus limited for the many expectant project beneficiaries. Therefore, there is the need to organize more and bigger collaborative projects with emphasis on sustainable

livelihood asset development that would create significant impacts to poor fishing households in coastal communities.

Mangrove crab

A decision theory approach was initiated to establish the optimal stocking density of mangrove crab hatchery production during dry and wet seasons, taking into account water temperature uncertainty and the risk tolerance of producers and farm decision-makers.

A first run completed the larval cycle (from early to crab instar) with a stocking density of 60 zoeas per liter, with observed average ammonia level at 0.88 ppm which is within acceptable range of ≤ 1 ppm. Nitrite level was 0.29 ppm which was higher than the normal threshold of ≤ 0.1 ppm but the crab larvae were able to tolerate it. Temperature (29.9°C) and dissolved oxygen (4.91) were within the optimum level (27-30°C and >4 ppm, respectively). Crab larvae survival was 1.00% which was reasonably satisfactory compared to the 80 zoeas per liter survival of 0.37%.

Subsequently, a second batch completed the larval cycle with a survival rate triple (3.4%) compared to the previous run while a stocking density of 80 zoeas per liter exhibited a lower survival rate of 0.8%.

These initial results indicate that mangrove larvae perhaps have a high tolerance of nitrogen loading in the environment. However, the generation of more data from recent stock batches was pending and waiting for breeders to spawn since the last hatched eggs that were subjected to a stress test were discarded due to poor quality. Bio-economic modeling and its analysis will be implemented when the required data set is completed.

Fish health & sustainable aquaculture

With support from the Government of Japan, information on aquatic health management continued to be produced through research and disseminated through trainings. Research and capacity-building projects on sustainable aquaculture were likewise pursued.



Small-scale solar-powered abalone hatchery, constructed at Molocaboc Island with support from the Government of Japan, trains fisherfolks on hatchery production of juveniles for stock enhancement.

Fish health management strategies

Development of rapid diagnostics

Artificial infection experiments using different weight ranges of *P. vannamei* were conducted for White Spot Syndrome Virus (WSSV) in order to determine the threshold levels of infection that can cause mortality in shrimp. The viral loads of WSSV present when the mortalities started was determined at 10^9 DNA copies/g, while for the survivors was 10^6 DNA copies/g. The threshold level of WSSV in shrimp was determined at 10^7 to 10^8 DNA copies/g and it was not weight dependent.

This information together with optimized protocol could be used to detect the target pathogen, serving as a reference in the monitoring and diagnostic schemes at the farms and enabling farmers and stakeholders to strictly monitor the health status of their aquatic animals affected by the aforementioned diseases. Thus, early and effective intervention strategies could be undertaken at the farm level.

Enhancement of vaccine efficacy

In preventing the incidence of viral nervous necrosis (VNN) in high-value marine fishes, the field efficacy of the formalin-inactivated nervous necrosis virus (NNV) was evaluated in pond-reared pompano. Intramuscular injection of a sublethal dose of NNV in pompano juveniles (average body weight 4.7) resulted in 0-15% mortality rate. The surviving fishes were re-challenged with a lethal dose of NNV at 1 and 2 months post-primary sublethal NNV injection. None of the fish died nor manifested any VNN associated symptoms. How-

ever, 70-80% mortality rates were observed in the control fish groups suggesting that in natural NNV infection, upregulation and subsequent proliferation of anti-NNV neutralizing antibodies play an important role in suppressing or controlling the progression of the disease.

Enhancement of shrimp immune response

The use of adjuvants, carriers, and RNAi technology for enhancing the antiviral immune response of shrimp to WSSV was examined to determine if the efficacy of combined recombinant proteins, rVP28 and dsRNA, as antiviral treatment against WSSV is effective. In tank trials, oral delivery using micro-particles to encapsulate the proteins at 1:3 ratios is most effective in reducing mortalities caused by WSSV infection. Although low-cost delivery and improved efficacy are needed in enhancing the resistance of shrimp by the application of immune-stimulating or virus-inhibiting compounds in shrimp culture, this result could only be adopted by

farmers once verified under actual field conditions.

Efficacy of garlic extract against parasites

A study was conducted to test the efficacy of orally administered garlic (*Allium sativum*) extract in powder form against *Trichodina* sp. in Nile tilapia. Results showed that tilapia fed with garlic extract supplemented diets showed significant reduction in the prevalence and mean intensity of *Trichodina* sp. parasites as compared to the control. Histological analysis of the gills and muscle of tilapia fed with garlic supplemented diet showed no signs of abnormalities whereas fragmented muscle, disarranged collagen bundle along the muscle, hyperplasia and lamellar fusion of the gills of tilapia were observed in tilapia fed the control diet.

In vitro results of garlic extract efficacy testing on *Trichodina* revealed that the time required for killing all *Trichodina* parasites was 45 mins at the lowest concentration (150 ppm) and 10 mins at the highest concentration (400 ppm).



The parasite *Trichodina* sp. with 50-micrometer scale bar

Acute toxicity bioassay to determine the 96h LC₅₀ value of garlic extract in pompano (*Trachinotus blochii*) were carried out in a static system. Results showed that the median lethal concentration (LC₅₀) of garlic extract to pompano for 24, 48, 72 and 96 h of exposure were 29.18, 23.31, 16.79 and 6.64 mg/L respectively.

Results demonstrated the potential of powdered garlic as a natural alternative to chemical treatments for eliminating parasites in tropical fishes. This also clarified the factors associated with the susceptibility or resistance of fish to some parasitic infection and established the disease transmission cycle which can be used to formulate the practical strategies for preventing future parasite infestation.

Epidemiology of EMS in tiger shrimp

Towards developing protective measures against VP_{AHPND}, which is one of the causative agents of the early mortality syndrome (EMS), it was previously observed that exposure of tiger shrimp (*Penaeus monodon*) to temperature at 35°C and salinities of 10 and 28 ppt could result in mortality. However, using greenwater, stocked with siganid for not less



Participants in the training on health management of freshwater fish in Myanmar last 16-21 December 2019

than two weeks, likewise provides protection against the disease and also improves shrimp growth and survival. When survival among shrimps with high and low VP_{AHPND} infection maintained in aged seawater was compared, low shrimp survival in shrimps with high infection was observed. Among shrimps with low VP_{AHPND} infection, higher survival was observed when the shrimps were maintained in seawater aged for 14-28 days (70% and 63%, respectively) compared to those maintained in seawater aged for 7 days (48%), and non-aged seawater (39%).

Technology extension and demonstration

An on-site training on health management of freshwater fish was organized by SEAFDEC/AQD in Myanmar on 16-21 December 2019. Fifteen participants were trained on major bacterial and parasitic diseases. Lectures enabled the fish health personnel to stay abreast on the latest issues on persistent and emerging transboundary diseases. The course both imparted theory and enhanced skills through lectures and hands-on exercises to enable participants to accurately diagnose bacterial and parasitic diseases.

Sustainable aquaculture

Plant-based protein in tilapia feeds for improved production

The use of agricultural wastes and by-products as feed ingredients to produce tilapia with improved traits continued to be explored. The previous tilapia feed formulation was refined to include other low-

cost feed ingredients such as poultry by-product meal. Indoor feeding trials of tilapia fingerlings were conducted to test six diet formulations, containing fermented (bacteria- and *Trichoderma*-treated) and non-fermented okara meal which were compared to a fishmeal-based diet. The three best performing diets (replacing fish meal with 30%

non-fermented okara meal, 30% *Trichoderma*-treated okara meal, and 15% bacteria-treated okara meal) were selected based on improved growth performance of tilapia fingerlings for further testing in tank- and lake-based cage conditions.

Aquasilviculture

Mangroves provide bioavailable food and nutrients for organisms in all tiers of the food web as well as improve water quality in ponds. Comparing the culture water quality and shrimp performance in aquasilviculture ponds (mixed and separate) and ponds with mangroves, higher shrimp survival was observed in separate (47%) and mixed (39%) aquasilviculture ponds, compared to non-aquasilviculture ponds (0%). As for WSSV load, this was higher in non-aquasilviculture pond (10^{11} copies/g) compared with that of the aquasilviculture ponds (10^6 copies/g). Water quality was also better in aquasilviculture ponds since they had a lower temperature, salinity, and ammonia levels.

Community-based production and resource enhancement

The Community-Based Resource Enhancement (CBRE) Project in Molocaboc Island, Sagay in central Philippines aims to maintain the marine ecosystem in the community through community-based production of high value but threatened aquatic resources through stock enhancement. Using hatchery-reared abalone and sandfish juveniles, strategies had been developed comprised of a series and combination of social activities and exploratory release of juveniles.

Social preparation strategies such as establishing collaboration among fisherfolk, local government and researchers were undertaken including the organization of the fisherfolk into what is now known as the Molocaboc Sea Ranchers Association (MOSRA) which has been officially registered with the Philippine Department of



Okara meal



Capacity enhancement lectures empower the local fishers at Molocaboc Island

Labor and Employment. The local fishery stakeholders of Molocaboc spearheaded the bottom-up promulgation of the first-ever abalone catch size regulation at >6 cm in 2010, and the eventual release of 11 batches of hatchery-reared abalone from 2011 to 2015 in a coralline area near their community. Participatory monitoring of catch showed that catch of abalone continued to increase.

Since 2015 and after abalone seeding, catch per unit effort of abalone continued to increase up to an average of >150 individuals

per hour dive of three divers. As for sandfish, there was an increase in survival, growth, and density, although its recovery was challenged by societal problems. The major impacts of the CBRE Project include having the resources in overfished areas rebuilt through releases of hatchery-reared juveniles, while the community-based and tri-party collaboration are enhanced to implement and manage the resource-enhanced sites. The solar-powered hatchery and nursery units for abalone and sandfish provide the assurance of the

sustainability of the CBRE Project because the juveniles can now be produced locally and on a small-scale basis. Regulations in abalone and sandfish harvesting had been established by the community, allowing only the harvest of abalone with >6 cm shell length and sandfish at 320 g live weight. Fishers in the area were not only provided income-generating livelihoods through harvesting but have been capacitated in aquaculture operations to enable them to become better stewards of the fisheries and the environment.

Resource enhancement of seahorses

Resource enhancement of seahorses was likewise carried out in Molocaboc Island, with trials on nursery rearing using natural food available in the local area as well as training of fishers in the community for seahorse culture. From those trials, the average number of seahorses increased to 33 per sampling from 30 per sampling in pre-

vious years. A community-based backyard hatchery of seahorse was built in the community using solar-powered aerators and utilizing available natural food such as copepods and mysid shrimps collected from the pilot site to feed the newborn and juvenile seahorses up to 4 months. Nursery rearing of juvenile seahorses was undertaken in submerged pens until the animals reached 7 cm stretched height.

Information, education, and communication campaigns, including lectures on seahorse biology and resource management, were also conducted annually to increase appreciation on the importance of seahorses in the wild.

Capacity-building

Transfer of the latest technologies and information on aquaculture to ASEAN Member States was undertaken through the training courses on Marine Fish Hatchery and Rural Aquaculture. The training on marine fish hatchery at the Tigbauan Main Station is a 37-day training that highlights

on the breeding, hatchery seed production, nutrition and health management of grouper, sea bass, and snapper. The 2019 training was attended by eight participants of whom four were funded by the Government of Japan.

Another activity conducted at the Binangonan Freshwater Station was a 10-day rural aquaculture training. Focus was given on the promotion of community-based freshwater aquaculture for remote rural areas of Southeast Asia. This year's training had four participants all of whom were funded by the Government of Japan.

Information sharing within the scientific community

Sharing of knowledge within the scientific community was pursued through the International Workshop on Promotion of Sustainable Aquaculture, Aquatic Animal Health and Resource Enhancement in Southeast Asia (SARSEA) 2019 organized in Iloilo City, Philippines on 25-27 June 2019. The workshop aimed to update participants, especially concerned authorities, on issues related to sustainable aquaculture, aquatic animal health, and resource enhancement, and to put forward recommendations to address the issues. Moreover, the workshop aimed to promote support for research and development towards wholesome and responsible aquaculture. Representatives of SEAFDEC Member Countries reported on the status of sustainable aquaculture, resource enhancement, and aquatic animal health in their respective countries while experts from SEAFDEC/AQD and other institutions imparted knowledge from their respective fields.



Locals attending to live food culture in the community-based hatchery and nursery for abalone, sandfish, and seahorse at Molocaboc Island

Info sharing on aquaculture a must in ASEAN

Global experts in aquaculture said that to enhance successes in resource enhancement and prevent failures in the aquaculture industry, member-countries of the Association of Southeast Asian Nations (ASEAN) must share information.

The appeal was made at the International Workshop on the Promotion of Sustainable Aquaculture, Aquatic Animal Health and Resource Enhancement in Southeast Asia (SARSEA) organized by SEAFDEC/AQD on 25-27 June 2019 at Richmond Hotel Iloilo.

The experts said sharing information among ASEAN member-countries was in view of the need

for stronger capabilities in the detection of diseases in aquaculture resources so that aquaculture industries and institutions engaged in aquaculture resource enhancement avoid repetitions of mistakes.

"Aquaculture is growing and the gap is really widening in terms of disease detection capability. I firmly believe that working together is much better than working in isolation. If we work together, we will be benefited much faster," said Dr. Arun Dhar, one of the workshop resource persons from the University of Arizona.

Other recommendations during the workshop funded by the government of Japan were the enforcement of the established guidelines on disease surveillance and disease reporting and the adoption of established guidelines for food safety and traceability.

On the other hand, SEAFDEC/AQD expert Dr. Jon Altamirano shared the same view as Dr. Dhar on enhancing information sharing among ASEAN countries, emphasizing during his synthesis of the workshop that there is insufficient awareness on resource enhancement successes and failures among ASEAN member countries.

There were also concerns about diseases in aquatic resources, with Mr. Akito Sato, Japanese Trust Fund Program Manager and SEAFDEC Deputy Secretary-General saying in his closing remarks, "I hope SEAFDEC/AQD and member countries continue activities for preventing aquatic disease in advance and promoting early warning more effectively as well as strengthening laboratory capacity for aquatic disease."

The participants, a total of 53, also reported on the status of sustainable aquaculture and resource enhancement and aquatic animal health of their respective countries.



Participants of SARSEA 2019 in Iloilo City, Philippines held 25-27 June 2019 (top).
The Meeting on the first day of session (above).

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.



Trainees learn to measure the size of crabs using a caliper

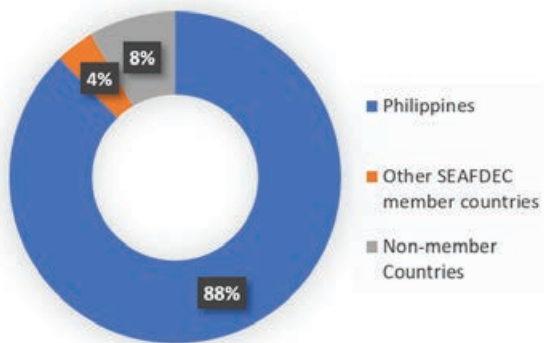
Overview

A total of 318 trainees participated in the 31 training courses organized this year with 19 nationalities represented. Profile of trainees revealed that 37% were private individuals, 25% identified with the academe, and 38% were government personnel. Participants from the Philippines continued to dominate the trainee population this year with 280 individuals (88%).

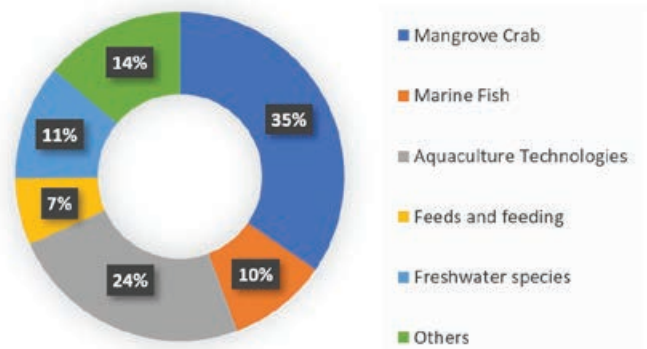
Mangrove crab technology drew the most interest among the commodities with 35% of commodity-based training participants, or 110 individuals, interested on various phases of mangrove crab culture. An equal share of trainees came from the government (38%) and the private sector (37%), with the remainder coming from non-government organizations.

The On-the-job-training Program catered to 236 students coming from 24 schools. This program allows the students, mostly senior high school (90) and bachelor's degree in fisheries (72), to complete their school requirements. Also, a total of five individuals signed up for the Internship Program to gain experience at the various AQD hatcheries.

Trainees by country



Participants by training topic



Trainees collect sandfish from pens at the Igang Marine Station



Trainees prepare larval rearing tanks at the marine fish hatchery

Regular Training Course

Course, date, venue	Total participants (Male/Female)	Countries represented by participants
Freshwater Prawn Hatchery & Grow-out Operations 18-22 February (BFS, Binangonan, Rizal)	7 (3 F, 4 M)	Philippines
Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery & Management 25 March-8 April (TMS, Tigbauan, Iloilo)	6 (1F, 5M)	Fiji: 3 Papua New Guinea: 1 Philippines: 2
Freshwater Prawn Hatchery & Grow-out Operations 20-24 May (BFS, Binangonan, Rizal)	11 (3F, 8M)	Malaysia: 1 Philippines: 10
Marine Fish Hatchery 24 June - 30 July (TMS, Tigbauan, Iloilo)	8 (5F, 3M)	Philippines: 7 Viet Nam: 1
Mangrove Crab Hatchery Operations 12 August - 2 September (TMS, Tigbauan, Iloilo)	14 (2F, 12M)	India: 1 Philippines: 13
Catfish Hatchery and Grow-out Operations 21 - 25 October (BFS, Binangonan, Rizal)	6 (M)	Nigeria: 1 Philippines: 5
Community-Based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia 18 November - 3 December (BFS, Binangonan, Rizal)	4 (2F, 2M)	Cambodia: 1 Philippines: 2 Viet Nam: 1

Specialized Training Courses

Course, date, venue	Total participants	Countries represented by participants
Mangrove Crab Fattening 28 - 30 January (TMS, Tigbauan, Iloilo) <i>Privately funded</i>	3 (2F, 1M)	Philippines
Mangrove Crab Nursery 1 - 2 February (New Buswang, Kalibo, Aklan) <i>Funded by KASAMA/Noryangjin</i>	10 (1F, 9M)	Philippines
Grouper Culture 4 February-1 March (TMS, Tigbauan, Iloilo) <i>Funded by Japan International Cooperation Agency (JICA)</i>	2 (M)	Cambodia
Fish Health Management 4 February - 1 March (TMS, Tigbauan, Iloilo) <i>Funded by JICA</i>	2 (1F, 1M)	Cambodia

Course, date, venue	Total participants	Countries represented by participants
Algal Culture 18 February - 1 March <i>Funded by Ruru Aquatic Hatcheries, Inc.</i>	1 (F)	Philippines
Feeds & Feeding Management 26 February - 5 March (TMS, Tigbauan, Iloilo) <i>Funded by BFAR-NFRDI, SEAFDEC/AQD, Private</i>	21 (10F, 11M)	Philippines
Aquaculture Technologies 1 April - 30 September (TMS, Tigbauan, Iloilo) <i>Funded by Tokyo University</i>	1 (F)	Japan
Capacity Enhancement in Science & Aquaculture for Science High School Teachers in Iloilo 21 - 24 May (TMS, Tigbauan, Iloilo) <i>Funded by Government of Japan</i>	23 (20F, 3M)	Philippines
Seaweed Culture 17-24 June (TMS, Tigbauan, Iloilo) <i>Funded by the Ministry of Fisheries & Research, Government of Bangladesh</i>	6 (1F, 5M)	Bangladesh
Mangrove Crab Hatchery, Nursery, & Grow-out Operations 15-29 July (TMS, Tigbauan, Iloilo) <i>Funded by BFAR Region 8, SEAFDEC/AQD</i>	12 (3F, 9M)	Philippines
Mangrove Crab Nursery & Grow-out Operations 5-12 August (TMS, Tigbauan, Iloilo) <i>Funded by BFAR Central Office</i>	14 (3F, 11M)	Philippines
Small-scale Inland Freshwater Aquaculture 5-23 August (BFS, Binangonan, Rizal) <i>Funded by JICA</i>	8 (3F, 5M)	Benin: 1 Cambodia: 1 Cameroon: 1 Cote d'Ivoire: 1 Ghana: 1 Kenya: 1 Myanmar: 1 Philippines: 1
Milkfish Culture & Management 26 August-1 September (TMS, Tigbauan, Iloilo) <i>Funded by BFAR Region 6</i>	15 (9F, 6M)	Philippines
Mangrove Crab Nursery & Grow-out Operations 9-16 September (TMS, Tigbauan, Iloilo) <i>Funded by the National Fisheries Authority-Government of Papua New Guinea</i>	3 (F)	Papua New Guinea
Mangrove Crab Nursery & Grow-out Operations 16-19 September (Bagamanoc, Catanduanes) <i>Funded by BFAR Central Office</i>	35 (8F, 27M)	Philippines
Mangrove Crab Nursery & Grow-out Operations 30 September - 9 October (TMS, Tigbauan, Iloilo) <i>Privately funded</i>	15 (4F, 11M)	Malaysia: 1 Philippines: 13 USA: 1

Course, date, venue	Total participants	Countries represented by participants
Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery & Management 3 - 18 October (TMS, Tigbauan, Iloilo) <i>Privately funded</i>	3 (M)	Philippines
Milkfish Hatchery 21 - 30 October (TMS, Tigbauan, Iloilo) <i>Privately funded</i>	4 (2F, 2M)	Philippines
Mangrove Crab Nursery & Grow-out Operations 4 - 13 November (TMS, Tigbauan, Iloilo) <i>Funded by FAO and LGU Sagay</i>	4 (M)	Philippines: 2 Tanzania: 2
Milkfish Hatchery 4 - 13 November (TMS, Tigbauan, Iloilo) <i>Funded by FAO</i>	2 (1F, 1M)	Tanzania
Aquaculture Technologies 7 - 8 November (Calapan, Oriental Mindoro) <i>Funded by LGU Calapan</i>	30 (8F, 22M)	Philippines
Grow-out Culture of Oyster 13 - 14 November (Roxas City, Capiz) <i>Funded by ISDABEST</i>	3 (F)	Philippines
Aquaculture Technologies 18 - 22 November (TMS, Tigbauan, Iloilo) <i>Funded by Filminera Mining Corp. / PhilGold Refining & Processing Corp.</i>	25 (3F, 22M)	Philippines
Aquaculture Technologies 25 - 29 November (TMS, Tigbauan, Iloilo) <i>Funded by Filminera Mining Corp.</i>	20 (3F, 17M)	Philippines

Internship and On-the-Job-Training

Course, date, venue	Total participants	Countries represented by participants
Internship at AQD hatcheries	5 (2F, 3M)	Philippines
On-the-job-trainings a requirement in academic institutions	236 (135F, 101M)	Philippines



Trainees sort crablets prior to stocking in ponds at the Dumangas Brackishwater Station



Philippine aquaculture officers observe feed mill operations as part of a training on feeds and feeding management



Trainees learn to prepare algal culture media



On-site training on mangrove crab nursery at Catanduanes, Philippines



Trainees measure the water temperature at the Mangrove Crab Hatchery



High school teachers are oriented on laboratory activities as part of a capacity enhancement training

"I consider AQD as a basket of knowledge and I promised to apply all the learnings I gained here to improve fisheries and aquaculture sector in my home country."

Elizabeth Forgako

Head
Ministry of Livestock,
Fisheries, and Animal
Industries (Cameroon)
Training on Small-scale Inland
Freshwater Aquaculture

"Ang makasama sa mga training na ganito ay isa sa matagal na naming kagustuhan.

Nagpapasalamat ako na kami ay nakitaan ng potensyal at kakayanan ng aming barangay para makadalo dito"

[We always wanted to join training courses such as this one.

We would like to thank our barangay for seeing our potential and ability to learn from this training]

Roque Betita

Fisherman (Philippines)
Training on Aquaculture
Technologies

"The training provided me with basic knowledge and application about milkfish culture and management. It could help me widen my perspective and know-how about the aquaculture industry and how I could be able to help in the info-dissemination and giving effective technical assistance and extension services."

Anonymous

BFAR Region 6 (Philippines)
Training on Milkfish
Culture & Management

"The lectures were good and really enjoyed the sessions and especially backed up with practicals. The biology of mangrove crabs really piqued my interest and provided a solid basis for identification especially with my line of work back in PNG especially with the new mangrove crab work I have begun to do."

Anonymous

(Papua New Guinea)
Training on
Mangrove Crab Nursery
& Grow-out Operations

"The training course was significant. In fact, crab industry has great market worldwide. Thus, the training gave us the idea and other technical aspects on how mangrove crab is being cultured and produced."

Manilyn O. Llenares

Aquaculture Technologist
BFAR Region 8 (Philippines)
Training on Mangrove
Crab Hatchery, Nursery &
Grow-out Operations

"This training is a vital tool in our aquaculture sector in Zanzibar because through knowledge and new skill and modern techniques we are going to spread and to share to our technician and also throughout the aquaculture sector in Zanzibar."

Said Juma Shaaban

Hatchery Technician
(Tanzania)
Training on
Milkfish Hatchery Operations

'Baskets' of expectations filled after sandfish training

Aiming to start a small-scale commercial sandfish hatchery, three Fijians searched the world over and found the platform they needed for learning the culture of the prized commodity at SEAFDEC/AQD in Iloilo, Philippines.

"We scan around the globe to see which among the institutions that can provide us the needed information and the skills required for us to succeed in our ventures. So we selected to attend the SEAFDEC/AQD training program..." said Solomon Suguta, one of the trainees from Fiji.

He shared their high hopes that the "baskets" of expectations they brought will be filled when they return to their respective countries.

"Indeed, our baskets were full with the 16-day training. Thank you so much [to] all the technical team for the practical skills, the lectures, the theories... we are so privileged to be attending the course," said Suguta.

The trainees from Fiji, together with one participants from Papua New Guinea and two from the Philippines, attended the 16-day training course titled "Sandfish (*Holothuria scabra*) Seed Production, Nursery and Management" held at Tigbauan Main Station in Iloilo, Philippines on 25 March-8 April 2019.

The training course covered lectures and practical activities on natural food culture, sandfish spawning induction, and larval rearing. Grow-out culture and sandfish processing were taken up as well during the course.



Trainees prepare to examine sandfish inside pens at the Igang Marine Station

Japan sponsors training of Iloilo HS science teachers

To improve the quality of science education in Iloilo, the Government of Japan sponsored a three-day training for 23 high school science teachers from 13 public high schools in the province.

Held from May 21 to 24 at SEAFDEC/AQD in Tigbauan, Iloilo, the science teachers received lectures from scientists and specialists on aquaculture principles, genetics and biotechnology, basic microscopy, and science research.

The teachers were hands-on in the training on reference management, statistical design and analysis, and writing a research proposal. As a final output, the teachers came up with simple and doable research proposals.

Mark William Sazon, science teacher of Mina National High School, said that the course was the most comprehensive, well organized, and most informative among the trainings he has attended.

"It is because of this training course I can say to myself that I'm already confident enough to face my students," he added.

The teachers expressed their gratitude to the Government of Japan for funding the training, as well as to SEAFDEC/AQD as the training organizer.

"To be honest, I'm a science teacher but in-depth analysis and techniques is not common to me because hapaw (superficial) lang ang amon knowledge about that one. So for the lecturers, thank you very much," said John Paul Frajillo of Guimbal National High School.



High school science teachers tour SEAFDEC/AQD laboratories during a Japan-sponsored training

Public communication and engagement

By disseminating technical and farmer-friendly information, whether through online platforms or in-person engagements, SEAFDEC/AQD aims to make an impact in aquaculture and society by making science accessible to the public.



Delegates of the 12th Asian Fisheries and Aquaculture Forum visit the SEAFDEC/AQD Sandfish Hatchery in April 2019

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SEAFDEC/AQD science paper wins prestigious award

A science paper by SEAFDEC/AQD was given the 2019 Dr. Elvira O. Tan Award for Outstanding Published Paper in Aquatic Science Category. The paper, "Immunization regimen in Asian sea bass (*Lates calcarifer*) broodfish: A practical strategy to control vertical transmission of nervous necrosis virus during seed production," was authored by Dr. Rolando Pakingking Jr. together with co-authors Dr. Evelyn Grace de Jesus-Ayson, Ofelia Reyes and Norwell Brian Bautista

Dr. Pakingking received the award during the S&T Awards and Recognition Ceremony of the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (DOST-PCAARRD) on 19 June 2019 at the Philippine International Convention Center, Pasay City, Philippines.

The Dr. Elvira O. Tan Award gives recognition to Filipino scientists and researchers for their exceptional publication of research and development results which support the mission of DOST-PCAARRD to advance the country's national economic and food security.



SEAFDEC/AQD scientist Dr. Rolando Pakingking Jr. receives the 2019 Dr. Elvira O. Tan Award for Outstanding Published Paper in Aquatic Science Category

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Publications

SEAFDEC/AQD produced a new farmer-friendly manual on nursery culture of tropical anguillid eels. The proceedings of the ASEAN Regional Technical Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia was also published. Information on some existing brochures were updated while QR codes were attached to new versions. A total of 42,030 copies of technical and scientific materials were printed in 2019.

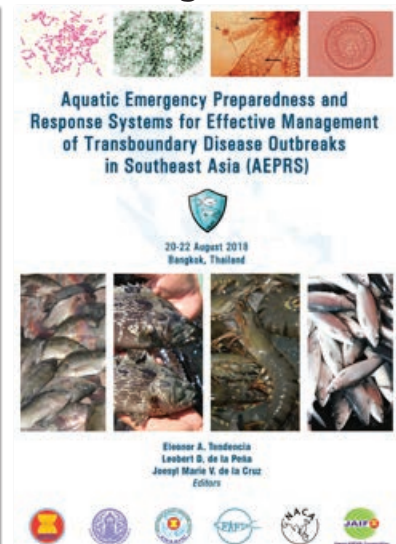
The AQD Matters newsletter continued to be produced and disseminated every two months.

Annual report



Highlights 2018 is SEAFDEC/AQD's annual report summarizing its accomplishments and progress for the year 2018

Proceedings



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

Extension manual



A manual on *Nursery Culture of Tropical Anguillid Eels in the Philippines* (AEM 65) released in April 2019

Newsletter



The AQD Matters newsletter continued to be released bimonthly in 2019

Online Platforms

WEBSITE



51,563

2019 UNIQUE VISITORS
Most visitors come from English-speaking countries (Philippines, U.S.)



273K

2019 PAGE VIEWS
Lower than 2018 due to change in search engine algorithm, shift to social media

REPOSITORY



1.69M

2019 DOWNLOADS
The repository offers free PDF downloads of SEAFDEC/AQD publications



3,485

ARCHIVED ITEMS
The figure is cumulative since 2011. For 2019, 211 items were archived.

SOCIAL MEDIA



17K

TOTAL FACEBOOK LIKES
Combined likes of Facebook pages (including Library, FishWorld)



72K

2019 YOUTUBE VIEWS
Views mostly from instructional videos of aquaculture commodities

Mass Media

Information dissemination through mass media continued to be ramped up in 2019. A total of 30 official press releases were sent to different media outlets. In all, SEAFDEC/AQD had 50 recorded appearances in newspapers/magazines, 51 news appearances in websites, and two appearances on national TV.

GMA Network (TV)

Unang Hirit, 1 February 2019
Born to Be Wild, 22 December 2019

Philippine Daily Inquirer

Bangus capital tapping wild fry to fill shortage (1 May 2019)

The Philippine Star

Ulang farmers target global shrimp market (6 October 2019)

Manila Bulletin

Villar pushes for sustainable fishing industry for food security (21 November 2019)

Philippine Information Agency

HS teachers train on aquaculture, science research (3 June 2019)
Global experts: Info sharing on aquaculture a must in ASEAN (12 July 2019)

Philippine News Agency

PH shrimp industry banks on gov't support to sustain growth (21 November 2019)

Tiger shrimp farming still a profitable venture (29 November 2019)

Agriculture Magazine

Mangrove crab hatchery in Northern Luzon to be upgraded (May 2019)

Panay News

Gov't lauds advances to lower cost of fish farming (6 November 2019)

Shrimp harvest in Dumangas lifts hopes for reviving sugpo farming (13 November 2019)

Popularity of mangrove crabs spurs trainings on crab farming (20 November 2019)

The Daily Guardian

BFAR-6 lauds push for revival of sugpo farming (2 December 2019)

More breeders boost SEAFDEC's drive to help develop bangus industry (27 December 2019)



Exhibitions

For 2019, SEAFDEC/AQD organized two exhibitions and participated in five. 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 eight thousand walk-in guests. Almost half of these visitors were logged during a five-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.



Exhibit guests examine SEAFDEC/AQD's shrimp pond diorama during the 12th Philippine National Shrimp Congress in Bacolod City



Visitors at the SEAFDEC/AQD booth during the 26th Agrilink



Booth during the 15th National Symposium on Marine Science



Pupils learn microscopy during the 2019 Regional Science and Technology Week of DOST-VI



SEAFDEC/AQD Aquaculture Week displays at SM City Iloilo

Exhibitions participated in or organized by SEAFDEC/AQD in 2019

Exhibition or Event	Exhibit Highlight	Date	Venue
15th National Symposium in Marine Science	Laboratory services	4-6 July	Banga, Aklan
46th Anniversary Program Exhibit	AQD Memoirs	12 July	TMS
SEAFDEC/AQD Aquaculture Week	SDG 14: Life below water	15-19 August	Iloilo City
56th Fish Conservation Week Exhibit	FishWorld, marine conservation	17-19 September	Iloilo City
AgriLink	Algae paste	3-5 October	Pasay City
2019 Regional Science and Technology Week and Iloilo Innovation Expo	Fish health	21-25 October	Iloilo City
12th Philippine National Shrimp Congress	Oplan Balik Sugpo	20-22 November	Bacolod City

FishWorld

FishWorld, SEAFDEC/AQD's visitor center and museum of aquatic biodiversity, received 11,049 guests in 2019. The Internship and On-the-Job Training Program of FishWorld, listed 72 student participants from three high schools in Iloilo and one in Antique.

The annual Aquaculture Week was participated by two universi-

ties, 26 senior high schools, 20 junior high schools and 21 elementary schools with about 176 students and 93 coaches joining the various Sci-Art Contests.

FishWorld also works on the conservation of endangered megafauna. For 2019, 12 sea turtles were brought to FishWorld after being rescued from fish traps or

found along the beach. Three of these turtles were released after tagging, two are undergoing rehabilitation, while the eight turtles that died were preserved. Also, 19 hatchlings from Tigbauan and Guimbal were released.



Grade school pupils participate in a nutrition and aquaculture quiz contest



Pupils prepare their entries to a contest on writing and drawing a children's story

Production and services

Seedstock and market-size commodities are produced as byproducts of research and verification activities. Several service laboratories also support the research needs of the Department as well as the private sector, academe, and government.



Over 7.2 tons of tiger shrimp (*Penaeus monodon*) were harvested in 2019 at the Dumangas Brackishwater Station

Hatchery and grow-out production

Production of some aquaculture seeds and market-size commodities significantly expanded in 2019 in view of intensified verification activities.

While tiger shrimp postlarvae production notably improved to 862,600 from just 492,600 in 2018, milkfish fry production continued to lead both in quantity and increase. Milkfish fry production in 2019 was 6.6 million from just 1.1 million in 2018. It must be noted, however, that the 2019 theoretical production capacity of the Department was 57.3 million if all milkfish larvae were stocked. To further increase the production of milkfish fry, the Department increased its stock of milkfish breeders. At the moment, 179 are actively spawning out of 346.

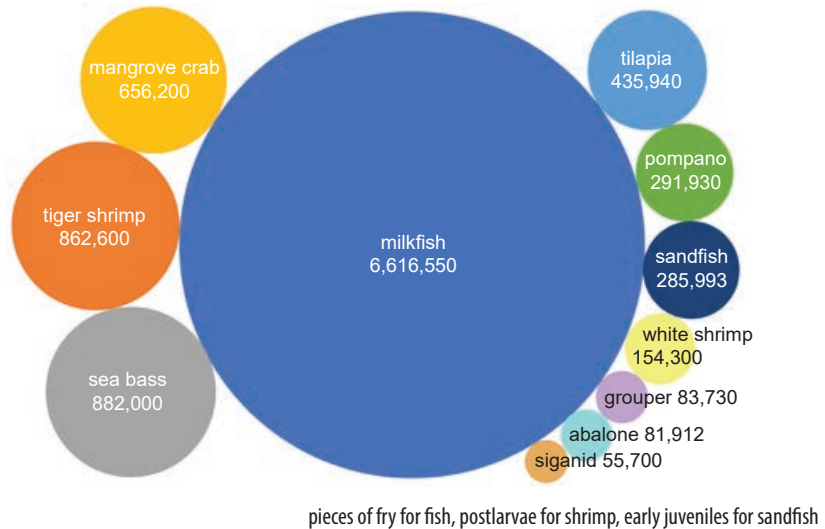
Farming of tiger shrimp and whiteleg shrimp began in 2019, yielding 7.2 tons and 13.2 tons, respectively. Milkfish harvests doubled to 17.3 tons from 8.6 tons in the previous year.

Larval food production

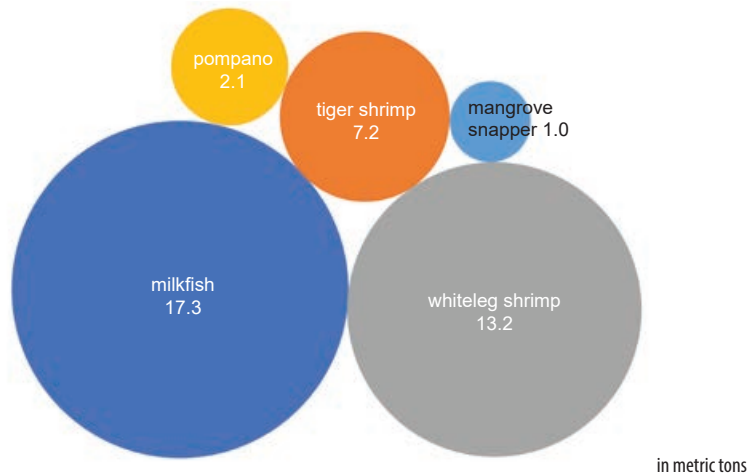
To support the research and production activities of the Department, the larval food laboratory served 29,544 liters (live) and 22.15 kg (paste) of microalgal, rotifer, and copepod starters. Additionally 9.62 kg (wet weight) of *Artemia* biomass were prepared.

The laboratory also catered to 219 clients from the private sector (local, 58.44%; foreign, 5.63%), academe (10.4%), and government institutions (25.54%). The items

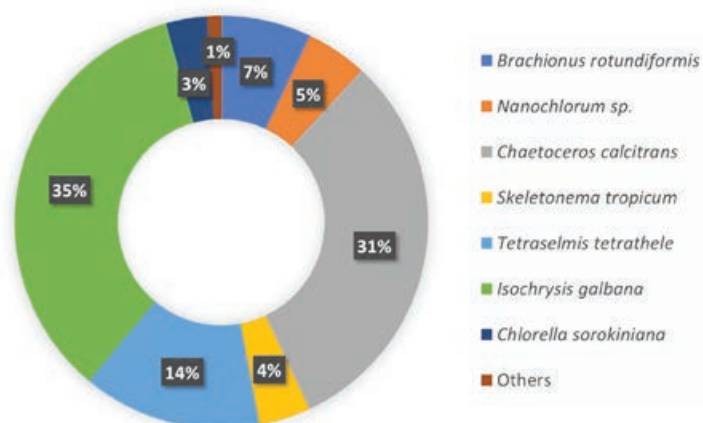
Seedstock produced and harvested in 2019



Market-size commodities harvested in 2019



Types of liquid starters disposed to stakeholders



New harvesting equipment for production of algal paste

An Evodos dynamic settler unit that uses spiral plate technology was acquired by SEAFDEC/AQD in 2019 to boost the production of algal paste. It is the first unit in the Philippines and the third in Asia.

Algal paste is an alternative to conventional algal food for fish larvae. Its use effectively lowers the cost of hatchery operations by eliminating the need for a laboratory facility and algal tanks which are expensive to build and maintain.

This new harvesting equipment is used to produce algal paste that can be used for all types of microalgae, according to Annie Franco, leader of the SEAFDEC/AQD Natural Food Commodity Team. "It is just a simple machine that separates the water from the live culture to produce a concentrated form," she said.

Moreover, this equipment is more efficient than conventional centrifuges when it comes to the dry weight of the output algae paste which can be used as a starter or for direct feeding to fish larvae.

"The Evodos dynamic settler can achieve a dry weight percentage of 200-400 grams per liter as compared to less than 150 grams per liter for other conventional centrifuges," said Franco. In addition, the dynamic settler has a separation efficiency of 95 percent and has a 100 percent retention of valuable cell components, leaving the algae intact and undamaged.



Natural food laboratory staff shows the algal paste produced by the new dynamic settler equipment

Feed mill upgraded to boost production of low-cost feeds

The quest for low-cost and eco-friendly aquafeeds received a boost with a US\$60,000 upgrade of the feed mill of SEAFDEC/AQD. A five-layer dryer and an extruder were acquired to further increase the capacity of the feed mill by 300 kilograms per hour or 2,400 kilograms per 8-hour workday. The extruder is used to produce both sinking and floating aquafeeds.

"The recent upgrade boosted the production rate by almost 400 percent. With the additional extruder, production will not be impeded by the periodic downtime for maintenance or unexpected breakdowns," said Joseph Biñas, head of the Nutrition and Feed Development Section.

Before the upgrade, the feed mill can only produce 500 kilograms per day due to the limited capacity of the ovens which is the main equipment used for drying feeds.

The feed mill produces diets for abalone, grouper, mangrove crab, milkfish, pompano, sea bass, shrimp, siganid, and tilapia as well as feed ingredients that are utilized for research projects of SEAFDEC and non-SEAFDEC researchers and graduate students. It also accepts orders from private hatcheries that needs maintenance feeds for marine fish breeders and larvae which are not readily available commercially.



The new five-layer dryer at the SEAFDEC/AQD feed mill

disposed included 3,914.76 liters of liquid microalgal/rotifer/starters, 541 g *Artemia* cysts, 34 tube cultures, 1 liter live *Artemia*, and pre-mixed fertilizers and culture media.

The laboratory also purchased an Evodos dynamic settler unit, an algae harvesting equipment that will be used for the production of microalgal paste.

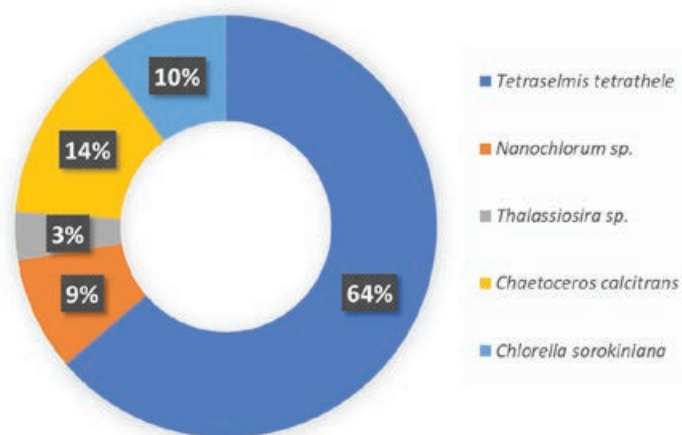
Feed mill production

Over 60 tons of aquafeeds for various commodities were produced by the Feed Mill in 2019. About 79% of these were produced for studies conducted at SEAFDEC/AQD. The rest were for external clients which included the academe (researchers and students) and private hatcheries. A new five-layer drier and extruder were also procured to increase the capacity of the facility from 500 kilograms to 2,400 kilograms per 8-hour workday.

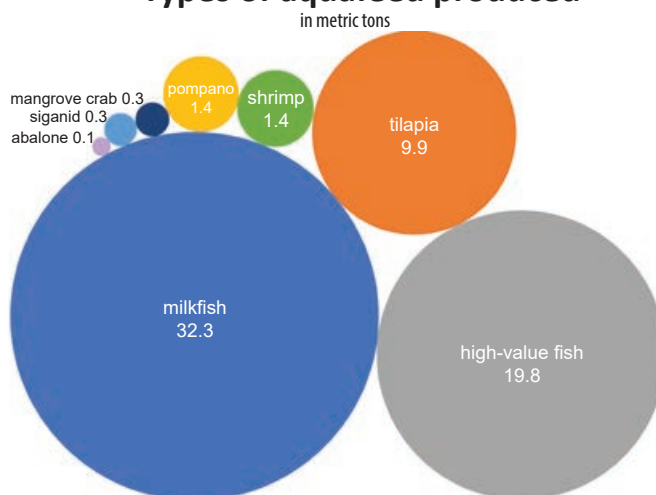
Analytical Services

The Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT) conducts proximate, water, soil, microbiological, and atomic absorption analysis as well as fatty acid profiling and electron microscopy. LFAAT accepted 1,910 samples most of which were analyzed in support of SEAFDEC/AQD's various research programs. Some samples on the other hand were submitted by stakeholders from the private sector and the academe. Bulk of the samples analyzed were water (1,151). Other services done were proximate analysis (297), soil (287), microbiological analysis (24), fatty acid profiling (24), electron microscopy (6), and atomic absorption spectroscopy (4).

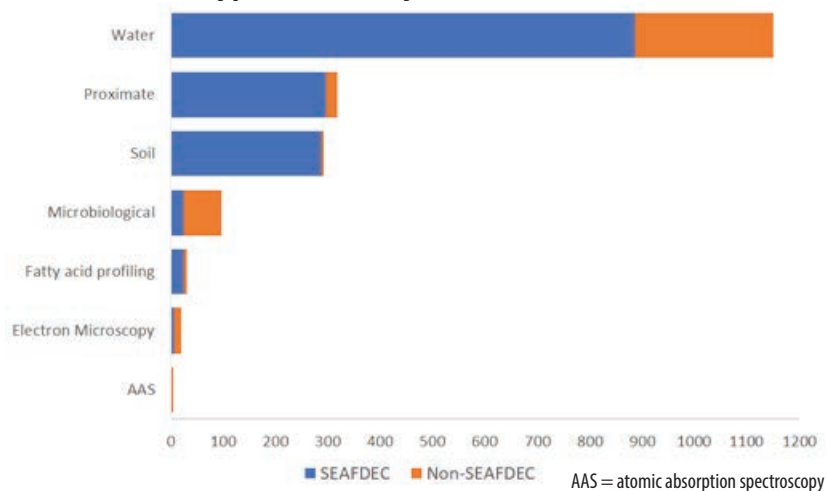
Types of microalgal paste produced



Types of aquafeed produced



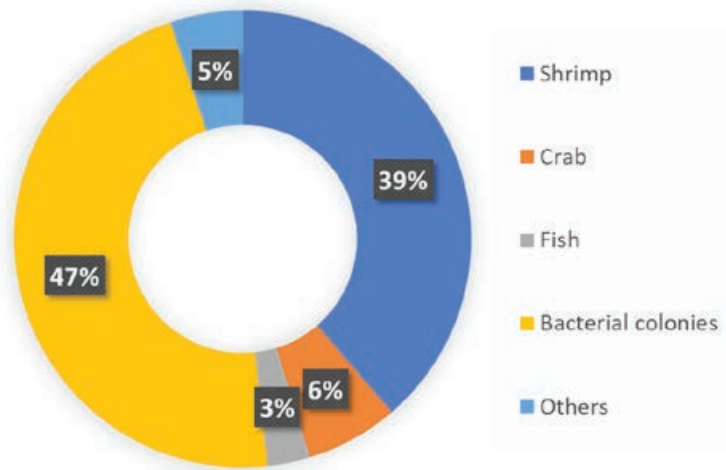
Types of analyses conducted



Diagnostic Services

The Fish Health Section handles diagnostic cases for a range of viruses, bacteria and parasites. Diagnostic services catered to 1,328 cases in 2019, mostly on bacterial colonies (47%). Diseases were detected mainly through polymerase chain reaction (PCR) with 1,932 samples analyzed. Acute hepatopancreatic necrosis disease (AHPND) was the most requested disease for diagnosis with 865 samples analyzed followed by white spot syndrome with 646 samples. Bacterial count

Types of diagnostic cases examined



New and improved analytical services at LFAAT

The Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT) now has the capability to detect the presence and concentration of heavy metals and other metallic elements in water and animal samples after its acquisition of an atomic absorption spectrophotometer (AAS).

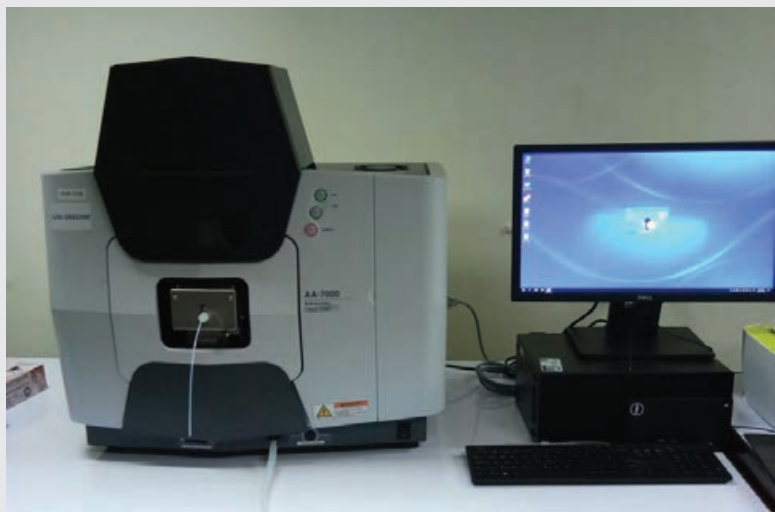
Engr. Margarita Arnaiz, LFAAT manager, said the new instrument will allow researchers to conduct studies on the food safety of aquaculture products, particularly on the levels of heavy metal contamination.

The AAS, a Shimadzu AA-7000 model, may also be used for the analysis of river effluent, sludge, airborne dust, semiconductors, ceramics, petroleum, oil, catalysts, chemical products, blood, plants, drugs and food products.

The laboratory's capability to detect *E. coli* and coliform bacteria also received a boost with the acquisition of instrumentation and its accessories to conduct a Colilert® test. The internationally approved method is specific to *E. coli* and coliform, simultaneously detecting their presence and quantity within 24 hours.

Engr. Arnaiz also announced the acquisition of a continuous flow analyzer (CFA), a Skalar SAN++, which now allows LFAAT to measure total ammonia-nitrogen in water samples. The CFA also improves the laboratory's capability to measure ammonia, nitrate and nitrite.

The LFAAT operates in support of SEAFDEC/AQD's research projects but also accepts samples from the public.



The new atomic absorption spectrophotometer of SEAFDEC/AQD

was also done on 817 samples and bacterial identification was done for nine samples with a total of 45 isolates. Meanwhile, the Microtechnique Laboratory released 1,027 slides and 15 blocks from 1,108 samples received.

Library services

The present collection of SEAFDEC AQD Library stands at 46,219 titles with 78,317 volumes or copies. The collections stand at 21,413 monographs, 5,697 SEAFDEC Publications, 18,699 bound serial volumes, 10,655 pamphlets, and a variety of maps, posters, microfiche and CD-ROMs. These were available for use and could be searched online through the AQD Library online public access catalog (OPAC).

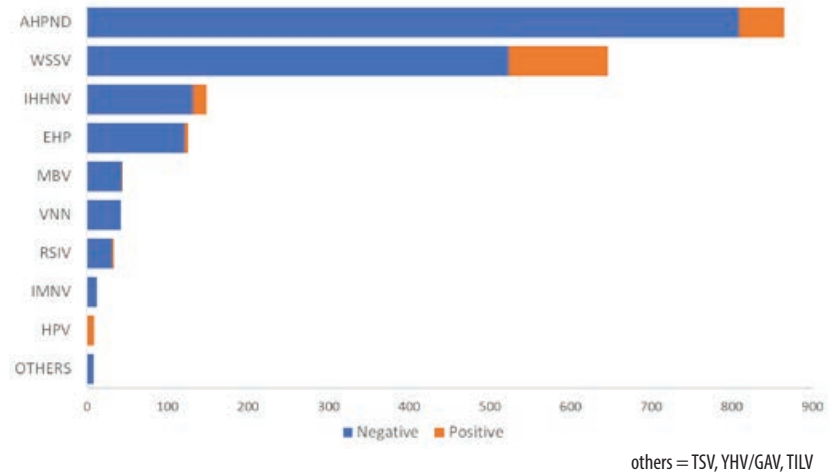
The OPAC was visited by a total of 4,307 global searchers. In addition, the library offers access to the following databases: ASFA, Springer, ProQuest Central, and TEEAL. The Library served 5,887 readers, 95% of whom were from different academic institutions in the coun-

try, 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 2,457 (1,691-SAIR; 766- in-house) document requests were catered from about 1,387 (1,252-SAIR; 135- in-house) individuals. Seventy-eight percent of the documents requested were placed thru the SEAFDEC/AQD Institutional Repository (SAIR). Ma-

majority of the requesters were from the Philippines, India, Malaysia, Indonesia, USA, Singapore, Thailand, United Kingdom, Sri Lanka, Denmark, Germany, Uganda, etc. The remaining percentage of documents requested were in person, and remotely, through email, phone, chat, and Facebook messenger, the majority by SEAFDEC/AQD employees.

Diagnosis summary



Human resources and finance

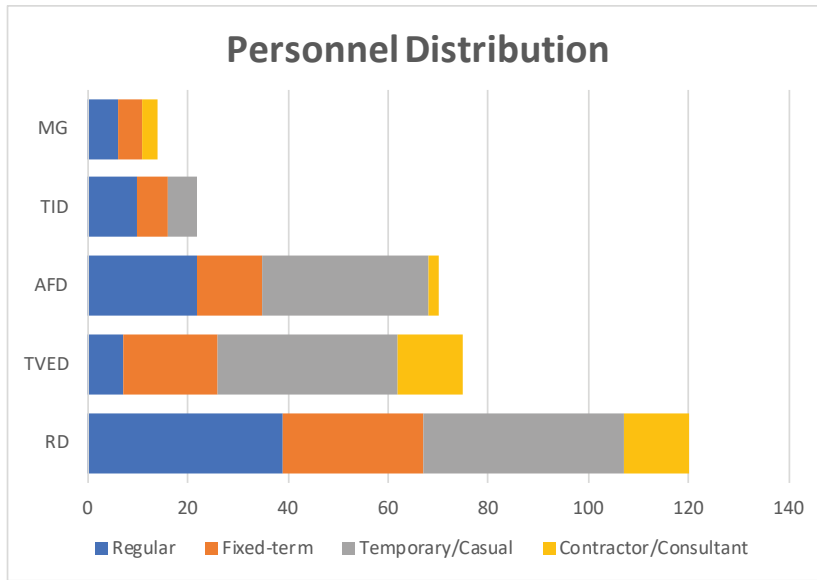
Various avenues were provided to enhance the capacity and promote the productivity of personnel who are behind the activities and accomplishments of the organization. Sound management of fiscal resources is imperative to maximize the output of activities and their benefit to stakeholders.



SEAFDEC/AQD personnel at the Multi-Purpose Hall during the kick-off of the 46th Anniversary Activities on 8 July 2019.

Personnel Distribution

As of end of 2019, SEAFDEC/AQD's personnel numbered 302 composed of 81 regular employees, 76 fixed-term staff, 117 casuals, and 28 contractors/consultants. The Technology Verification and Extension Division (TVED) had the most staff (101) assigned to it, followed by the Research Division (RD) with 95, Administration and Finance Division (AFD) with 69, and the Training and Information Division (TID) with 21. The Management Group involved 16 personnel.



Santiago says experts must work together, brainstorm



Dr. Alfredo Santiago, former SEAFDEC/AQD Chief, delivers his speech during the 46th Anniversary Program in July 2019

Former SEAFDEC/AQD Chief Dr. Alfredo Santiago called on researchers to go beyond their box of expertise, work together, and pool their ideas to further the development of aquaculture.

In his keynote message during the SEAFDEC/AQD 46th Anniversary Program on 12 July 2019, Dr. Santiago noted that SEAFDEC/AQD has all the expertise to support the generation of quality and sustainable aquaculture technologies but emphasized that experts must work as a team.

“Brainstorm and apply the interdisciplinary approach in conducting research,” said Dr. Santiago

who was also a senior researcher prior to becoming chief of SEAFDEC/AQD from January 1983 to April 1986.

“With the advances in information technology, everyone should be aware of what is going on in other places, countries, and find out techniques that can be improved and adopted to existing aquaculture technologies,” he said, addressing the SEAFDEC/AQD community assembled at the Multi-Purpose Hall.

The former SEAFDEC/AQD Chief also said that research outputs must reach the fish farmers and fish culturists through education, training and extension.

“Cooperation with private sector, government agencies, and other international agencies must also be pursued,” he said.

Finally, he challenged the researchers and scientists to “make the SEAFDEC Aquaculture Department a consistent leading agency in the further development of sustainable aquaculture technologies that address food security.”

In the early years of SEAFDEC/AQD, Dr. Santiago was instrumental in the establishment of tiger shrimp maturation pens in Guimaras which eventually became the Igang Marine Station. This paved the way for the completion of the tiger shrimp life cycle in captivity, the first major breakthrough of SEAFDEC/AQD which catapulted the institution to international prominence.

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, 10 personnel were sent to four international and five local events. Of these, one presented a paper in the oral category of a conference. One was also allowed to conduct with partial funding of dissertation at SEAFDEC/AQD. Another was granted study leave pay to attend summer classes of a masters degree program.

Scientists awarded for contributions to aquaculture



Dr. Frolan Aya, with family, receives his award from NAST in July 2019

Dr. Frolan Aya received the 2019 Outstanding Young Scientist Award in the field of environmental science from the Philippines' National Academy of Science and Technology (NAST). The award acknowledged his significant contributions in the field of fisheries science and aquaculture, particularly on the breeding and culture of indigenous aquatic species, stable isotope ecology, and fish nutrition. The NAST is the highest recognition and scientific advisory body of the Philippines.

Retired senior scientist Dr. Emilia Qunitio also received the 2019 Outstanding Professional in Fisheries/Aquaculture which was given by the Philippines' Professional Regulation Commission. The award recognized her contributions to the growth of the mangrove crab industry.

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

Event	Date	Location
International Association for Social Science Information and Technology (IASSIST) Annual Conference	27-31 May 2019	Sydney, Australia
Training Course on Basic Virological Techniques	24-28 June 2019	Muntinlupa, Metro Manila
Hands-on Training on Statistics and Measurement Uncertainty in Chemical Analysis	3-4 June 2019	Century Park, Manila
American Chemical Society (ACS) National Meeting and Expo	24-29 August	San Diego, California, USA
50th National Annual Convention and 69th Foundation Anniversary of Occupational Health Nurses Association of the Philippines	3-4 September 2019	Quezon City
Designing Pay Structures	12-13 September 2019	Mandaluyong City
International Conference of Aquaculture in Indonesia 2019	3-5 October 2019	Surabaya, Indonesia
Purchasing Management	3 October 2019	San Juan City, Manila
International Training Program on Biofloc Technology	2-7 December 2019	Bangkok, Thailand

Summary of Grants Received

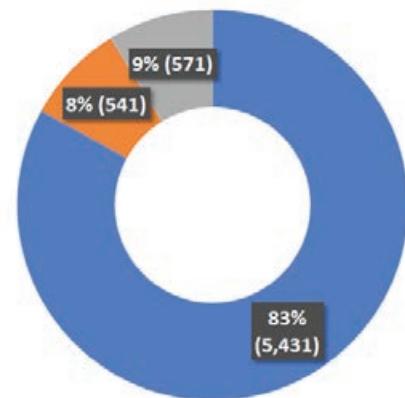
Organization	Scope	Amount (US Dollar)
Japan Asean Integration Fund (JAIF)	Workshop on Eel Culture and Statistics in the Philippines (April 2019)	23,013
Australian Centre for International Agricultural Research (ACIAR)	Breeding and seed production of giant grouper (Jan 2014-Sept 2019)	67,716
Bureau of Fisheries and Aquatic Resources (BFAR)	Establishment of Multi-Species Hatchery/Nursery Facilities (Jan 2018-Dec 2019)	153,746
Australian Centre for International Agricultural Research (ACIAR)	Increasing technical skills supporting community-based sea cucumber production in Vietnam and the Philippines (Jan 2016-Dec 2019)	41,358
The Scottish Association for Marine Science (SAMS)	Safeguarding the future of the seaweed industry of the Philippines: Disease and Pest Detection (Jan-Dec 2019)	40,154
Japan International Research Center for Agricultural Sciences (JIRCAS)	Demonstration and verification of sustainable and efficient aquaculture techniques by combination of multiple organisms (Jan-Dec 2019)	19,538
Bureau of Fisheries and Aquatic Resources (BFAR)	Establishment of mangrove crab seed banks, nurseries and grow-out production farms in the Province of Catanduanes (Jan 2018-Dec 2019)	30,277
National Fisheries Research and Development Institute (NFRDI)	Field testing of low cost aquaculture feed for milkfish and tilapia in ponds and cages (Jan 2018-Dec 2019)	134,564
Japan International Research Center for Agricultural Sciences (JIRCAS)	Development of low fish meal feed for aquaculture using alternative resources (Jan-Dec 2019)	1,653
Department of Science and Technology (DOST)	Molecular mechanism underlying <i>Scylla serrata</i> response to white spot syndrome virus (WSSV) infection (Jan-Dec 2019)	1,772
Food and Agriculture Organization of the United Nations (FAO)	Digitisation, Open Access Deposition and the Provision of URL to existing ASFA Records (Aug 2018-July 2019)	13,850
TOTAL		527,640

Statement of Financial Position

(US Dollar '000)		
	As of Dec. 31, 2019	As of Dec. 31, 2018
ASSETS		
CURRENT ASSETS		
Cash and cash equivalents	4,5914	3,203
Accounts Receivables	363	295
Materials and Supplies	15	19
Other current assets	2	2
Total Current Assets	4,975	3,519
NON-CURRENT ASSETS		
Cash investments	274	274
Other non-current assets	215	279
Total Non-current Assets	489	553
TOTAL ASSETS	5,464	4,073
LIABILITIES		
CURRENT LIABILITIES		
Accounts Payable	525	400
Funds Held-in-Trust	202	268
TOTAL LIABILITIES	727	668
NET ASSETS		
Designated	4,737	3,405
Undesignated	-	-
Unrealized Gain on AFS		
Financial Assets		-
TOTAL NET ASSETS	4,737	3,405
TOTAL LIABILITIES AND NET ASSETS	5,464	4,075

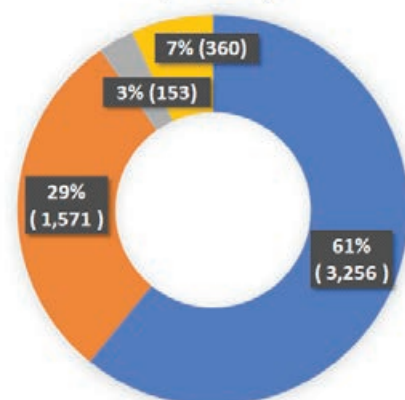
Note: US\$1.00 =PHP50.64.

Sources of Funds
('000 USD)



- Government of the Philippines
- External Grants
- Internally-generated Income

Allocation of Funds
('000 USD)



- Research Programs
- Administrative & Non-Project Expenses
- Training Programs
- Information Programs

STATEMENT OF REVENUES & EXPENDITURES (US Dollar '000)		
	Period ending	Period ending
	As of Dec. 31, 2019	As of Dec. 31, 2018
REVENUES		
Contributions / Grants	6,062	5,045
Other Income	546	556
TOTAL REVENUE	6,608	5,601
EXPENDITURES		
Research Programs	3,293	2,865
Training Programs	161	153
Information Programs	366	360
General Administrative and Non-Project Expenses	1,585	1,539
TOTAL EXPENDITURES	5,405	4,918
BALANCE	1,203	683

New collaborations in 2019

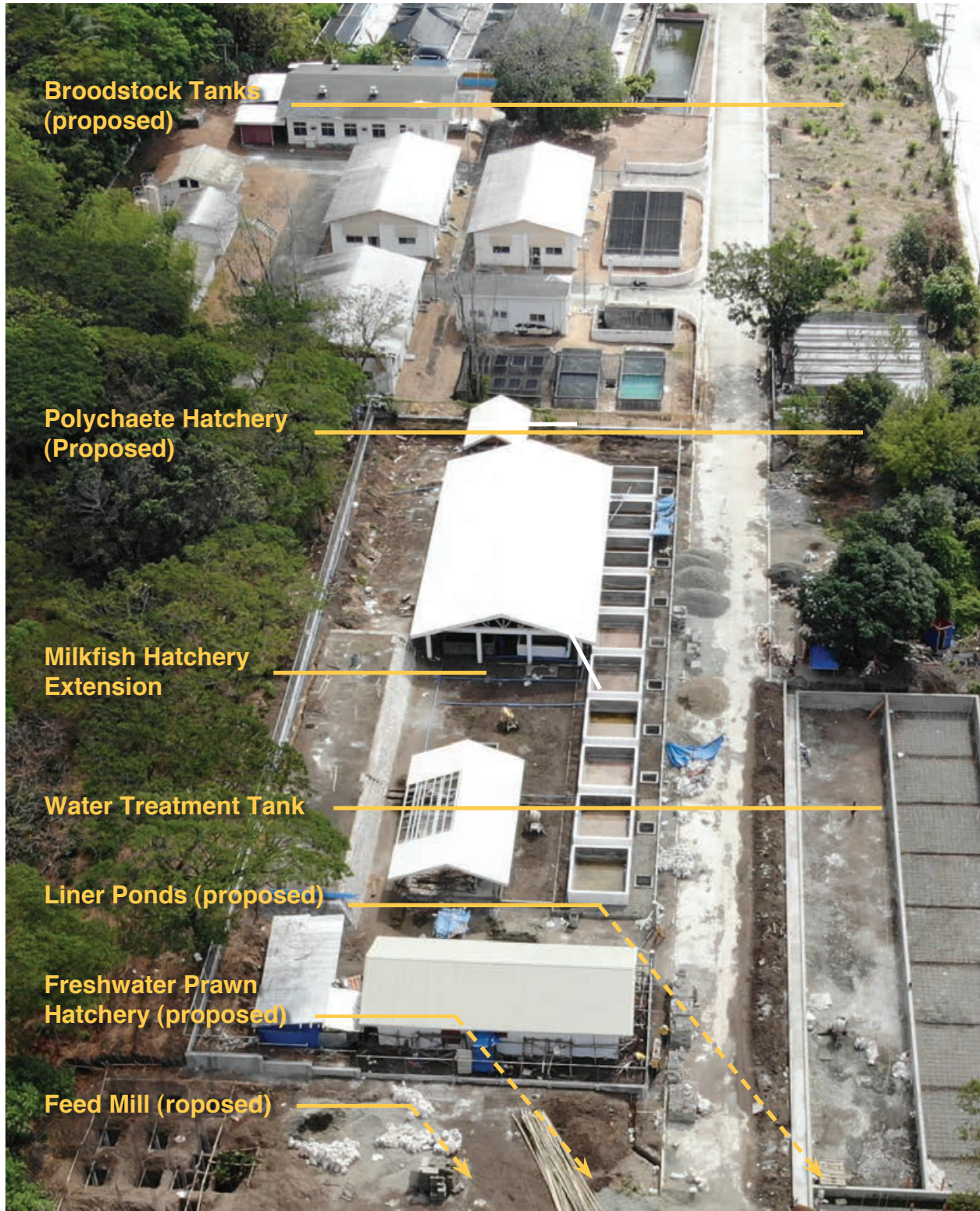
Academe

Partner Institution	Nature of collaboration	Period
University of Antique	Provide on-the-job training to students	2019 - 2020
University of the Philippines Los Baños (National Institute of Molecular Biology and Biotechnology)	Purchase of enriched copra meal from UPLB through BIOTECH to be used for research activities	2019
Partido State University	Provide technical advice and participate in some field activities in the resource enhancement site and in fisherfolk community meetings in Lahuy Island, Caramoan Camarines Sur	2019
St. Paul University Iloilo	SEAFDEC/AQD may invite SPU Iloilo faculty, researchers, and graduate students to undertake specific research projects where SEAFDEC/AQD lacks sufficient expertise or human resources which SPU Iloilo can provide SEAFDEC/AQD and SPU Iloilo may invite each other as resource person in training programs and extension activities	2019-2024

Government and Non-Government Organizations

Partner Institution	Nature of collaboration	Period
Food and Agriculture Organization of the United Nations	Production of no less than 850 full-text PDF files of documents published by SEAFDEC for deposition in open-access repository, preparation of approx. 600 ASFA records for inclusion in the ASFA database and providing links for approx. 250 digitized documents with existing ASFA records	2019
Bureau of Fisheries and Aquatic Resources - Central Office	Additional Project on Marine Hatchery specified as JLC Farm located in Mabini, Compostella Valley	2019
Bureau of Fisheries and Aquatic Resources	Capacitate selected staff from DA-BFAR, Catanduanes Provincial Agriculture Office, concerned Municipal Local Government Unit; crab gatherers, stockers, operators; and those who are involve in crab culture related activities in the province of Catanduanes; Conduct Training of Trainers on Mangrove crab; Establish on-farm technology demonstration in Catanduanes;	2019

Ongoing and proposed infrastructure projects at the Tigbauan Main Station



2019 Heads of offices

Executive Committee

Chief	Mr. Dan Baliao
Deputy Chief	Dr. Koh-ichiro Mori
Head, Research Division	Dr. Leobert de la Peña
Head, Technology Verification and Extension Division	Mr. Dan Baliao (until 24 Sept.) Dr. Roger Edward Mamauag (beginning 25 Sept.)
Head, Training and Information Division	Dr. Edgar Amar
Head, Administration & Finance Division	Ms. Amelita Subosa

Station Heads/OIC

Binangonan Freshwater Station	Dr. Maria Lourdes Aralar (until 14 Feb.) Dr. Frolan Aya (beginning 15 Feb.)
Dumangas Brackishwater Station	Mr. Victor Emmanuel Estilo
Igang Marine Station	Mr. Mateo Paquito Yap
Manila Office	Ms. Anna Maria Josefa Ortiz (until 22 July) Ms. Christine Joy Catig (beginning 23 July)

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. Jon Altamirano
Meeting social and economic challenges in aquaculture	Dr. Nerissa Salayo
Regional programs	Dr. Koh-ichiro Mori

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 (until 24 Sept.) Mr. Joseph Biñas (beginning 25 Sept.)
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. Hermoso Igcasan Jr.
Human resources management	Ms. Sunshine Mae Salonga
Budget-cashiering	Ms. Jiji Rillo
Accounting	Ms. Jo Anne Coronel



Research Division staff and friends at the SEAFDEC/AQD anniversary program in July 2019



Technology Verification and Extension Division staff and friends at the SEAFDEC/AQD anniversary program in July 2019



Training and Information Division staff and friends at the SEAFDEC/AQD anniversary program in July 2019



Administration and Finance Division staff and friends at the SEAFDEC/AQD anniversary program in July 2019



Southeast Asian Fisheries Development Center
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 Terengganu, Malaysia (1992) for the development and management of fishery resources in the exclusive economic zones of SEAFDEC member countries, and
- The Inland Fishery Resources Development and Management Department (IFRDMD) in Palembang, Indonesia (2014) for sustainable development and management of inland capture fisheries in the Southeast Asian region.

AQD is mandated to:

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

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

