

SEAFDEC/AQD

Highlights 2017



Aquaculture Department
Southeast Asian Fisheries Development Center
ANNUAL REPORT



SEAFDEC celebrates half a century of fisheries development

BANGKOK — SEAFDEC capped the year-long celebration of its 50th anniversary with a Golden Jubilee program in 15 November 2017 which was attended by government officials of member countries, representatives from international fisheries and donor organizations, as well as personalities who have made significant contributions to the history of SEAFDEC.

SEAFDEC/AQD chief Dan Baliao, former chiefs Rolando Platon and Alfredo Santiago, Jr., and Deputy Chief Chihaya Nakayasu attended the program which was graced by Air Chief Marshall Prajin Juntong, Deputy Prime Minister of the Kingdom of Thailand as guest of honor.

During the program, the Philippine Government was recognized for its contribution to SEAFDEC/AQD since 1973 “that prompted AQD to attain advances in aquaculture technologies leading to the sustainability of fisheries in the Southeast Asian region.” Joselito Piñol, representing the Philippine Government, received the tokens of appreciation during the anniversary program.”

Earlier that day, SEAFDEC Council Director for the Philippines Eduardo Gongona attended the Special Meeting of the SEAFDEC Council which adopted the “Resolution on the Future of SEAFDEC,” including the new Vision, Mission, and Strategies Towards 2030. During the same meeting, Dr. Flor Lacanilao, AQD Chief for 1981-1982 and 1986-1992, was awarded as among the outstanding SEAFDEC staff.



Flags of member countries. A parade of flags reminisces the 50-year history of SEAFDEC during the Golden Jubilee event.



AQD at the SEAFDEC Golden Jubilee event. From left: SEAFDEC/AQD chief Dan Baliao, Deputy Chief Chihaya Nakayasu, Administrative Assistant Janelli Garbay, Scientist Dr. Maria Lourdes Aralar, SEAFDEC/SEC fisheries technical officer Virgilia Sulit, Philippine Government representative Joselito Piñol, former SEAFDEC/AQD chiefs Dr. Alfredo Santiago, Jr. and Dr. Rolando Platon, Manila Office head Anna Maria Ortiz, and Special Departmental Coordinator Rex Delsar Dianala.



Token for the Philippine Government. Joselito Piñol (left) receives the tokens of appreciation for the Philippine Government’s hosting of SEAFDEC/AQD from Air Chief Marshall Prajin Juntong, Deputy Prime Minister of Thailand.

Baliao is new SEAFDEC/AQD Chief

Dan D. Baliao has been appointed to head SEAFDEC/AQD effective 7 September 2017 to serve a two-year term.

A former researcher and aquaculture specialist at SEAFDEC/AQD, the new Chief was endorsed by the Philippine Department of Agriculture which was then nominated by Philippine President Rodrigo Duterte to the SEAFDEC Council. His nomination was approved by majority of the Council Directors consisting of representatives from SEAFDEC member countries.

Baliao has previously headed AQD's Technology Verification & Commercialization Division, Administrative & Finance Division, Dumangas Brackishwater Station, and the former Leganes Research Station. He has published papers in peer-reviewed scientific journals and authored numerous aquaculture extension manuals covering commodities such as milkfish, black tiger shrimp, white shrimp, freshwater prawn, grouper, mangrove crab, and tilapia.

He has also previously served as International Consultant of the Food and Agriculture Organization of the United Nations and served in assignments to Myanmar, Palau, Timor Leste, Kiribati, Marshall Islands, and the Philippines.

Baliao obtained his MSc in Fisheries (major in Aquaculture) from the University of the Philippines (UP) in 1978 and his BSc in Biological Sciences from UP Iloilo in 1974.

The Chief's message



For 44 years, AQD has labored with pride as we addressed food security, wealth creation, and environmental concerns. While leadership changed hands time and again, AQD has always remained committed to fulfill its mandates of promoting and undertaking research, developing human resources, and promoting information dissemination and exchange. These mandates are grounded on the challenge of an ever-increasing human population and the rising demand for sustainable seafood sources.

With over four decades of research work in our hands, AQD will be intent on strengthening technology transfer programs to translate the knowledge we have

generated into reliable, cost efficient and environment-friendly technologies. We are expanding our efforts to equip stakeholders with science-based knowledge and skills that can be translated to more fish for the people and livelihood for the masses.

Meanwhile, our researchers will continue to search for solutions to the challenges of today's aquaculture. Among the challenges we are taking on is the revival of the tiger shrimp industry which, for years, has been beleaguered by diseases. As we make concerted efforts to improve culture and monitoring protocols and lowering production costs, we look forward to the day when the industry will be globally competitive again.

It is a special year as we mark the 50th anniversary of SEAFDEC. The collective accomplishments of the different SEAFDEC departments are many, far-reaching and ingrained in the history of the Southeast Asian region. Yet more needs to be done. Our achievements only inspire us to do even more to place more food on the table of the generations to come. Our stakeholders can count on that.

Dan D. Baliao
Chief, SEAFDEC/AQD



OPLAN BALIK SUGPO

BACOLOD CITY — The new banner program of SEAFDEC/AQD, *Oplan Balik Sugpo* which aims to revive the tiger shrimp industry in the Philippines, was launched at the sidelines of the 11th National Shrimp Congress on 18 November.

In the presence of shrimp industry players, Chief Dan Baliao bared his plans to address the gaps in the farming of the prime commodity, particularly in the aspect of disease prevention, detection and control. A practice of growing shrimp only during a “safe season” is also being drawn up, taking into consideration factors like temperature, photoperiod and bird migration.

Other approaches from the research teams at SEAFDEC/AQD are tackling different challenges in broodstock development, breeding, nutrition and feed development. With these concerted efforts, it is hoped that a globally-competitive shrimp industry will once again rise.



Contents

| | |
|--|----|
| Message of the Chief | 1 |
| Table of contents | 2 |
| 2017 Research and Development Programs | 3 |
| DEPARTMENTAL PROGRAMS | |
| Quality Seed for Sustainable Aquaculture | 7 |
| Healthy and Wholesome Aquaculture | 14 |
| Maintaining Environmental Integrity Through Responsible Aquaculture | 17 |
| Adapting to Climate Change | 20 |
| Meeting Social and Economic Challenges in Aquaculture | 22 |
| REGIONAL PROGRAMS | |
| Promotion of Sustainable Aquaculture and Resource Enhancement | 26 |
| Training Program | 33 |
| Information Dissemination and Public Awareness | 38 |
| Services and Extension | 50 |
| Human Resources and Finance | 56 |
| 2017 Heads of Offices | 61 |

2017 SEAFDEC/AQD HIGHLIGHTS

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Front cover: Tiger shrimp (*Penaeus monodon*).
(photo by JM dela Cruz)

Research & Development Programs in 2017

THEMATIC PROGRAMS

| Study Title | | Main Proponent | Collaborating Partners |
|---|---|-----------------|------------------------|
| Quality Seed for Sustainable Aquaculture | | | |
| 1 | Reproductive performance in Indian prawn <i>Penaeus indicus</i> broodstock fed polychaete-enriched diets | SSS Avanceña | |
| 2 | Effects of water depth, temperature and methyl farnesoate on the mating behavior and reproductive performance of captive and wild black tiger shrimp (<i>Penaeus monodon</i>) broodstock | EG Estante | |
| 3 | Refinement of rearing and feeding techniques for sustainable mass production of polychaete | MAE Mandario | |
| 4 | National Mud Crab Science and Technology Program: Program Title: Refinement of mud crab hatchery technology; Project Title: Sustainable production of mud crab through selective breeding | ET Qunitio | DOST-PCAARRD |
| 5 | Improvement of the performance of captive <i>Penaeus monodon</i> (Project 5) | FDP Estepa | DOST-PCAARRD |
| 6 | Utilization of artificial illumination in floating net cages on the nursery culture of <i>Pompano Trachinotus blochii</i> : effects on growth and survival of pompano and its added economic value | JLQ Laranja Jr. | |
| 7 | Tank-based nursery production of sandfish <i>Holothuria scabra</i> juveniles | JP Altamirano | |
| 8 | Potential of locally available microalgal strains as food for the minute monogont rotifer, <i>Proales similis</i> de Beauchamp | AV Franco | |
| 9 | Developing transport techniques for milkfish, <i>Chanos chanos</i> , juveniles | JIL Aquino | |
| 10 | Increasing abalone juvenile production through improved hatchery culture techniques. Subtitle 1: Use of chemical cues (positive ions, algal extracts) to improve settlement rate; Subtitle 2: Improve culture efficiency with the use of new tank design, orientation of plates and recirculating system; Subtitle 3: Use of anaesthetic agents as muscle relaxant for efficient sorting and harvesting of abalone juveniles | MR de la Peña | DOST-PCAARRD |

| Study Title | Main Proponent | Collaborating Partners |
|--|--------------------------|---------------------------|
| 11 National R&D Program for Blue Swimming Crab: Program Title: Hatchery and nursery operation for blue swimming crab, <i>Portunus pelagicus</i> : Project 2 - Development of the nursery technology for the blue swimming crab, <i>Portunus pelagicus</i> | FDP Estepa | DOST-PCAARRD |
| 12 Improvement of larval rearing protocol for <i>Portunus pelagicus</i> | ET Qunitio | DOST-PCAARRD |
| 13 Improvement of reproductive performance of abalone through refinement of broodstock management and selective breeding (DOST Study Title, Project 1) Substudy 1: Improvement of fecundity and seed quality of breeders recently acquired from the wild; Substudy 2: Evaluation of genetic stocks for selective breeding in abalone; Substudy 3: Increase survival rate of veliger larvae through improvement of harvest and incubation protocol | MR de la Peña/ MRR Eguia | DOST-PCAARRD |
| 14 Development of diet to improve broodstock breeding performance and larval quality of sandfish <i>Holothuria scabra</i> | JB Biñas | |
| 15 Cage culture of polychaetes in brackishwater pond | VR Alava | |
| 16 Use of <i>Nanochlorum</i> paste in mangrove crab seed production | JJDC Huervana | |
| 17 Production of <i>Kappaphycus</i> plantlets | MRJ Luhan | |
| 18 Promotion of livelihood opportunities in freshwater aquaculture I. Small-scale giant freshwater prawn hatchery seedstock production II. Urban agri-aquaculture as a livelihood option III. Skills training on urban agri-aquaculture | MRR Eguia | |
| 19 Large-scale production of donkey's ear abalone, <i>Haliotis asinina</i> juveniles | DD Catedral (NC Bayona) | |
| 20 Increasing abalone juvenile production through improved hatchery culture techniques. Subtitle 1: Use of chemical cues (positive ions, algal extracts) to improve settlement rate; Subtitle 2: Improve culture efficiency with the use of new tank design, orientation of plates and re-circulating system; Subtitle 3: Use of anaesthetic agents as muscle relaxant for efficient sorting and harvesting of abalone juveniles | MR de la Peña | |
| Healthy and Wholesome Aquaculture | | |
| 21 Evaluation of protein enhanced copra meal as a dietary protein source for economically important finfish | RE Mamauag | |
| 22 Effect of thraustochytrid on reproductive performance of hatchery-bred abalone, <i>Haliotis asinina</i> | RBS Taan | |
| 23 Quantitative amino acid requirements of juvenile Asian sea bass (<i>Lates calcarifer</i> Bloch): Requirements for leucine, isoleucine and histidine | RMA Cabrera | |
| 24 Evaluation of milkfish by-product hydrolysate as ingredient in larval diets for freshwater finfish, tilapia (<i>Oreochromis niloticus</i>) | RE Mamauag | |
| 25 Use of commercial probiotics (PRO W, PRO 2) and disinfectant (PUR) to control acute hepatopancreatic necrosis disease (AHPND) and luminescent vibriosis in <i>Penaeus vannamei</i> | LD de la Peña | INVE Asia Limited (China) |

| Study Title | Main Proponent | Collaborating Partners | |
|--|--|------------------------|--------------|
| 26 | Effects of Poly- β -hydroxybutyrate-accumulating <i>Bacillus</i> species on the water quality and thermal stress response of <i>Penaeus monodon</i> post larvae during culture | JLQ Laranja Jr. | |
| 27 | Hatchery production and semi intensive pond culture of <i>Penaeus indicus</i> | SS Avanceña | |
| 28 | Commercialization of soft-shell crab production | JIL Aquino | |
| 29 | Establishment of sanitary quality of oysters (<i>Crassostrea iredalei</i>) and their culture environments | RV Pakingking Jr. | DOST-PCAARRD |
| 30 | Prevention and mitigation of diseases in cultured mudcrab | EA Tendencia | DOST-PCAARRD |
| Maintaining Environmental Integrity through Responsible Aquaculture | | | |
| 31 | Giant freshwater prawn culture in lake-based cages: Strategies to improve production through stock manipulation and management | MLC Aralar | |
| 32 | Refinement of culture techniques for <i>Caulerpa</i> | MRJ Luhan | |
| 33 | Giant freshwater prawn culture in biofloc system | MLC Aralar | |
| 34 | Grow-out of abalone in small islands and/or community | MJHL Ramos | DOST-PCAARRD |
| 35 | Refinement of existing oyster grow-out techniques | MJHL Ramos | DOST-PCAARRD |
| 36 | Culture trial for sandfish <i>Holothuria scabra</i> in ponds and sea ranch | JP Altamirano | ACIAR |
| 37 | <i>Kappaphycus alvarezii</i> farming and its use as fertilizer for cacao tree | HT Sollesta | INSOL |
| Adapting to Climate Change | | | |
| 38 | Resiliency of <i>Gracilariopsis heteroclada</i> (Zhang et. Xia) to different salinities and pH | MRJ Luhan | |
| 39 | Changes in soil and water parameters and plankton profile in relation to weather conditions during pompano nursery culture | JL Valenzuela | |
| Meeting Social and Economic Challenges in Aquaculture | | | |
| 40 | Economic benefits and losses in seaweed farming in Guimaras, Philippines due to some climate change indicators | RJG Castel | |

REGIONAL PROGRAMS (GOJ-TRUST FUND)

| Reinforcement and optimization of fish health management and effective dissemination in the Southeast Asian Region | | | |
|---|---|-------------------|--------|
| 41 | Enhancement of vaccine efficacy for the prevention of viral nervous necrosis in high value marine fish | RV Pakingking Jr. | GOJ-TF |
| 42 | Establishment of protective measures against persistent and emerging parasitic diseases of tropical fish | GE Pagador | GOJ-TF |
| 43 | Application of adjuvants, carriers and RNAi technology to enhance the antiviral immune response of shrimp to WSSV | EC Amar | GOJ-TF |
| 44 | Epidemiology of the early mortality syndrome (EMS) in <i>Penaeus monodon</i> | EA Tendencia | GOJ-TF |

| | | | |
|----|---|-------------------|--------|
| 45 | Technology extension and demonstration | RV Pakingking Jr. | GOJ-TF |
| 46 | Development and acceleration of rapid and effective fish and shrimp health management. Subtitle: Establishment of threshold infection levels of WSSV and other pathogens such as VP _{AHPDN} in penaeid shrimp | LD de la Peña | GOJ-TF |

| Study Title | | Main Proponent | Collaborating Partners |
|--|--|------------------|------------------------|
| Environment-friendly, sustainable utilization and management of fisheries and aquaculture resources | | | |
| 47 | Responsible aquaculture through aquasilviculture | EA Tendencia | GOJ-TF |
| 48 | Use of plant-based protein sources in tilapia feeds for improved production traits | FA Aya/ MR Eguia | GOJ-TF |
| 49 | Promotion of resource enhancement of seahorses | SMB Ursua | GOJ-TF |
| 50 | 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

| | | | |
|----|--|---------------------|--------|
| 51 | Development of Integrated Multi-trophic Aquaculture (IMTA) techniques for livelihood improvement | M Kodama/ ND Salayo | JIRCAS |
| 52 | Development of low fish meal feed for aquaculture using alternative resources | Tsuyoshi Sugita | JIRCAS |

Abbreviations used

| | |
|--------------|---|
| ACIAR | Australian Centre for International Agricultural Research |
| DOST-PCAARRD | Department of Science and Technology - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development |
| GOJ-TF | Government of Japan - Trust Fund |
| INSOL | Innovative Solutions |
| JIRCAS | Japan International Research Center for Agricultural Sciences |

Quality Seed for Sustainable Aquaculture

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



***Penaeus monodon* postlarvae.** Weight gains of *P. monodon* postlarvae significantly improved when fed 2% taurine.

Development of good quality broodstock

To develop quality broodstock, stock characterization via molecular markers are utilized as these aid in determining the genetic quality of hatchery stocks. This, apart from information on reproductive efficiency and production traits, helps formulate suitable broodstock management protocols. Molecular markers (e.g. mtDNA and/or microsatellite markers) were used for genetic characterization of abalone (*Haliotis asinina*) and the mangrove crab (*Scylla serrata*). Nutritional intervention is also being done to improve reproductive traits. Better breeding stocks of tiger shrimp, Indian prawn, sandfish, tilapia and giant grouper are also being developed.

Abalone

Six microsatellite or short tandem repeat (STR) DNA markers were used to characterize the existing AQD abalone hatchery stock and nine wild stocks for broodstock genetic assessment. Identified

abalone stocks/strains showing high genetic variability mean they could be genetically better or more fit/ adaptable. Agusan del Norte (Mindanao) and Palawan (Luzon) stocks had the highest variability based on the number of alleles ($A = 17.8$ and 15.5) and expected heterozygosity ($Hexp = 0.861$ and 0.901) while the lowest genetic variability was noted in the Sagay (Visayas) stock ($A = 5$, $Hexp = 0.792$). The AQD hatchery stock from Iloilo (Visayas) had variability indices slightly higher than those from Sagay ($A = 8$ and $Hexp = 0.872$).

Spawning batches were also set up to compare the reproductive efficiency of the various strains. Molecular marker variation data were obtained and later correlated with breeding performance. When compared for reproductive efficiency, the AQD hatchery-bred abalone stocks had the highest fecundity which is expressed as

number of eggs per gram body weight (BW) female. Among the wild stocks, Zamboanga del Sur broodstock had the highest number of eggs while the Pangasinan broodstock produced the most number of eggs/g BW female. In terms of larval survival, stocks from Cebu had the highest recorded rate. This information and those obtained from the molecular marker variation assessment shall be used in the formulation of a broodstock management and selective breeding scheme for the abalone.

Mangrove Crab

Genetic characterization of mangrove crab stocks based on three novel and three existing STR markers is being done to assess the genetic quality and check for the negative impacts of domestication in several generations of selected and control stocks from Camarines and Surigao. Thus far, raw data based on uncorrected estimates of the number of alleles (A) showed that the parental stocks from Camarines and Surigao had 10.17 and 10.33 number of alleles respectively while two batches of the first generation Camarines control stocks were lower at 6.67 and 6.5 respectively and one batch of the first generation Surigao control stock had 6.33. Slightly lower A estimates were noted in the first-generation selected stocks from Camarines (6.17 and 6.5) and Surigao (4.0). Expected heterozygosity estimates were not significantly different between the stocks and across generations based on the existing batches screened. Molecular marker data are being correlated with parameters for selected beneficial



Abalone hatchery stock are being characterized along with wild stocks from different Philippine provinces for broodstock evaluation

traits to determine if the markers could be used as preliminary indicators of genetic improvement.

Tiger Shrimp

To best understand conditions that encourage/facilitate mating in the tiger shrimp (*Penaeus monodon*), experiments that would determine differences and problems in breeding performance of male and female spawners from captive and wild environments are being conducted. Video documentation on the reproductive behavior (pursuit of females by males and vice versa and number of mating episodes) of adult tiger shrimp during trials separately exposing spawners to varying depth, temperature and methyl farnesoate (a hormone that could induce female crustacean molting and reproduction) are on-going. Histological and gonad morphology evaluation of the male breeders are also being done. No mating has been observed thus far. The wild and captive male shrimps appeared to pursue wild female shrimps more frequently than the captive ones. More trials are necessary.

In another study, incorporation of vitamin C in the shrimp broodstock diet reduced incidence of mortalities in domesticated shrimp broodstock. When young postlarval stages (for on-growing to potential broodstock size) were fed 2% taurine, mass weight was significantly higher compared to treatments with lower taurine levels. In comparing reproductive performance of spawners reared in pens against those grown in tanks, tank-reared stocks resulted in maturation until stage 2 but no stocks matured in the pens.

Polychaete meal is to be incorporated in the formulated



Biofloc tested for suitability as feed for early stage polychaetes

broodstock diet given to adult Indian prawn stocks to determine the effect of these diets on male sperm quality, female ovarian maturation and reproductive performance. Polychaete meal and the test diet have been analysed for proximate composition and stability.

Sandfish

The development of an appropriate diet to improve breeding performance and larval quality in sandfish, *Holothuria scabra*, is on-going. The basic biological composition (protein, lipids, fatty acids etc.) of wild and hatchery-produced sandfish were determined. Using the proximate composition of wild-caught mature sandfish as reference, the appropriate practical diet is being developed to ensure that the nutritional requirements for enhancing breeding performance in adult sandfish are met. Preliminary data on feeding trials suggest that sandfish may require only low dietary levels of both protein and lipid, and that high lipid

content may be unfavorable to growth (though not necessarily to maturation).

Giant grouper

The focus of the study is to develop technologies for giant grouper (*Epinephelus lanceolatus*) aquaculture. The study started with the collection of giant grouper broodstock from local sources and these are being kept at the Igang Marine Station for regular monitoring of gonadal maturity. Molecular characterization of the stocks has been done while induced spawning trials have commenced. Hybridization has been tried by crossing a female giant grouper with male tiger grouper and further trials will continue in 2018.

Polychaetes

This year, the effectiveness of biofloc was compared against other natural food items as starter feed and settlement substrate for early stage polychaetes (*Marphysa spp.*) Critical stages during early development of polychaetes are also being

identified. Egg hatchability and larval development of polychaetes subjected to varying irradiance and photoperiod treatments are also being investigated. The

optimum stocking density and sediment depth requirement of the polychaetes during their nursery and grow-out phases are being determined apart from the effect of

light exposure on the growth and survival of the polychaete.

Refinement of hatchery and nursery management to improve seedstock production

To increase production of larval and juvenile stages of important aquaculture species, enhancements in laboratory and field-scale production of natural food organisms and alternative food items which serve as early stage diets are being evaluated. Improvements on rearing conditions and interventions to increase survival of aquatic organisms during larval development are also being assessed.

Abalone

Abalone studies have been done to determine the effectiveness of using chemical cues (positive ions, algal extracts) to improve settlement rate and increase production of juveniles. Moreover, efficient sorting and harvesting protocols using a muscle relaxant to improve the survival rate of abalone juveniles were developed. In determining the effectiveness of algal cues as settlement inducer, the presence of agar-bound microparticulate diet and ammonium chloride (NH_4Cl) apart from the diatom *Nitzschia* sp. resulted in consistently higher settlement rates — 12.06% and 2.83% after 5 and 10 days, respectively. In just *Nitzschia* sp. the settlement rates were 5.11% and 1.95%. Trials were also made on the application of potential chemical cues (NH_4Cl , GABA and serotonin) in bigger tanks. Application



Experimental setup on the use of artificial illumination in the floating cage culture of pompano

of NH_4Cl was tried in 1.5-ton fiberglass tanks in combination with *Arthrospira platensis* and *Nitzschia* sp. for abalone settlement. Highest settlement rate of 4.49% was attained after 5 days, while settlement after 10 days was 1.95%.

Blue swimming crab

The larval rearing protocol for the blue swimming crab (*Portunus pelagicus*) focused on the refinement of feeding and water management strategies to increase the survival rate of the megalopa and crab instar. The formalin stress

test, previously established to distinguish good from poor quality larvae, is being promoted for use in hatcheries to ensure that only the good quality larvae are used for further rearing. The protocols for hatchery and nursery-rearing of the blue swimming crab are being optimized. Crab instar 1-2 have been shown to tolerate salinities of 16-32 ppt. Later stages (crab instar 3) showed tolerance to 8-20 ppt, but higher survival was achieved at 16-32 ppt. Crab molting interval and increments were similar in all salinities from 16-32 ppt. The optimal stocking density for the

blue swimming crab during the second nursery rearing phase in hapas within pens was established at 10-15 individuals/m².

Mangrove crab

For ease in the hatchery rearing of mangrove crab seedstock, the use of algal paste in rotifer cultures for mangrove crab seed production was evaluated. *Nanochlorum* paste was first used in rotifer culture but *Tetraselmis* paste proved to be a better option hence further establishment of protocol for the use of *Tetraselmis* paste will be done to improve the growth and density of rotifer compared to the *Nanochlorum* batch culture.

Pompano

Pompano are opportunistic feeders as they can readily feed on wild zooplanktons present in ponds or in fish cages in marine waters. The idea of attracting wild zooplanktons to serve as supplemental food in the culture of pompano by artificially lighting the nursery net cages is being explored. This study was conducted to reduce costs in feeding formulated diets to caged pompano during its early stages.

Milkfish

For milkfish (*Chanos chanos*), a study that aims to develop a protocol in transporting juveniles (with an average total length of 5-6 inches) from the nursery to sea cage facilities has been started. This experiment hopes to define optimal temperature and salinity requirements for their transport. Preliminary findings show that survival of milkfish juveniles a week after being transported for 4 to 6 hours at 25°C regardless of salinity levels (0 to 20 ppt) still attained high survival (94

-100%). In contrast to the first two transport period trials, transporting milkfish juveniles at 25°C under higher salinities still results in good survival. However, the lowest survival percentage was 78.08%. Prolonging the transport time to 12 hours does not have any adverse effect on the juveniles.

Sandfish

To optimize growth and survival of sandfish juveniles to 20 g fingerling size, rearing was divided into two nursery phases: primary nursery phase for early juveniles (<5 mm to > 40mm or 3 g) and secondary nursery phase for late juveniles (3 g to > 20 g). The use of shaded and open hapa-in-tank nurseries



Culture of rotifers in 50-L fiberglass tank fed with *Nanochlorum* batch culture and algal paste



Size of milkfish juveniles used in the transport experiment

in rearing sandfish were compared. Results showed that growth of sandfish juveniles in shaded tanks was twice greater than those in open tanks during the first month. On the second month of rearing, sandfish in the open tanks grew faster.

Larval food

The potential of locally-available microalgal strains as food for the minute rotifer, *Proales similis* de Beauchamp, was evaluated. The biochemical, proximate and cost of production of the *Chlorella sorokiniana* microalgae

was established. Semi-batch culture trials show lower cost of *C. sorokiniana* paste production is achievable. Also, *P. similis* was found to tolerate high salinity (30ppt) but better results are obtained if acclimatization is done prior feeding with the algae.

Promotion of technically and economically-viable breeding and seed production schemes

To ensure that breeding and seedstock production methods developed at AQD are cost-effective, technologies are verified on farm. Nile tilapia (*Oreochromis niloticus*) and giant freshwater prawn (*Macrobrachium rosenbergii*) seed are produced to serve the needs of small-scale prawn farmers in the vicinity and verify/demonstrate methods for urban agri-aquaculture (aquaponics) in the Binangonan Freshwater Station (BFS), primarily using tilapia and/or prawns. Despite the small-scale production, the total tilapia produced from seed production tanks from March to December was about 111,284 pcs of fry and 70,744 pcs of A-net size seedstock. On the other hand, 53,970 fry and 29,145 A-net size seedstock were obtained from the tank meant for producing potential broodstock. All the seedstock produced were stocked in cages for on-growing to fingerlings/juveniles and then sold.

Freshwater prawn broodstock (BFS hatchery-bred stock; 1 male: 4 females/tank) were set up in 12 units of spawning tanks. Postlarvae (PL) production data from January to August 2017 was recorded at 248,094 pcs with a 54.11% survival



Portable aquaponics setup to explore the possibility of promoting the technology as a livelihood

to PL and mean number of days of metamorphosis to PL at 43. As early as April, breeder performance has been noted to be poor with no PLs being produced. Potential spawners were thus obtained from Isabela province. These broodstock were set up for spawning in September. By October, PL production totaled 33,771 with a 65% survival to PL. November data was noted at 26,427 PL production with stocks still awaiting metamorphosis to PL. December production gave 101,840 hatchlings awaiting

metamorphosis to PL, most of which are to be expected in January 2018.

To verify demonstrate and promote prawn/tilapia based urban agri-aquaculture technologies, a greenhouse and two portable aquaponics systems have been constructed. For the first set-up, kangkong (*Ipomea aquatica*) seedlings were transplanted to the aquaponics substrate (1 cocopeat:1 carbonized rice hull: 1 fine sand: 1 plain rice hull). Giant freshwater

prawns (12 pcs, ave wt: 10.74g) and red tilapias (40pcs, ave wt: 34.8g) were stocked separately in the tanks with the red tilapias fed daily with fish pellets. For the second set up, pechay (*Brassica rapa*) were planted in the pots while tilapias were stocked in the blue drum that served as the fish holding tank. Training on these potential aquaculture-based livelihood opportunities will be

conducted after being able to demonstrate that the aquaponics system is technically feasible.

Abalone juvenile production is also on-going. From September 2016 to August 2017, a total of 68,503 abalone juveniles (5mm – 8mm SL) were harvested with an average survival rate of 0.60%. Harvested abalone juveniles were reared further in the nursery tanks until

they reached 1.1 – 1.5 cm or larger and were ready for disposal. A seed production scheme using reduced flow-through system was tested. This scheme produced an average of 3,008 abalone juveniles with a survival rate of 1.09%. Control runs, however, resulted to an average of 2,548 abalone juveniles while survival rate averaged at 0.93%. Further runs will be made using larger 10-ton tanks.

Healthy & Wholesome Aquaculture

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



Oyster raft. This is one of the rafts, located in an approved area in Ivisan, Capiz Province, Philippines, used in the oyster relaying experiment. *E. coli* counts significantly dropped after a 2-week relaying period.

Finding alternative protein sources to replace fish meal

Copra meal is about 21% crude protein. Increasing the level of protein in this feed ingredient would make it a valuable replacement for fish meal. Protein-enhanced copra meal (PECM) is a potential alternative protein source in diets of high value species such as grouper, *Epinephelus coioides*. This product was analyzed for nutrient profile and included in different levels in grouper diet. The optimum inclusion level of PECM, its nutrient digestibility and the effect on liver and distal intestine morphology

of grouper are currently being assessed.

Lipid source is an important component in the formulated diet of abalone (*Haliotis asinina*) breeders. The algae thraustochytrid has a good profile of fatty acids and would be a good alternative source for fish oil. The optimum amount of thraustochytrid in the abalone breeder diet was determined. So far, the amount of crude fat in the mass-produced thraustochytrid was low (1.8-2.8%). Isolates were

prepared in petri dishes to increase the crude fat content of the algae. Crude fat in isolates increased to 20%.

Milkfish by-product is rich in protein and has high potential as a feed ingredient. Processing this into a hydrolysate using an enzyme could improve its utilization. Milkfish by-product hydrolysate was evaluated as a feed ingredient in the diet of tilapia, *Oreochromis niloticus*. Confirmatory tests are ongoing due to low survival rates

Promote practices or strategies to improve production

Postlarvae of *Penaeus indicus* were successfully produced in the hatchery and stocked for grow-out culture. Better performance was noted in shrimp fed a commercial diet low in crude protein content (40%) which will be verified in another run. Male with sperm and mated female were noticeable during harvest and could be sources of breeders. A collaboration was agreed with a farmer to use his pond for the grow-out culture of hatchery-bred *P. indicus* where all inputs are documented to determine profitability of *P. indicus* semi-intensive pond culture.



Stocking of *Penaeus indicus* PL 15 into a pond for grow-out culture

Testing the efficacy of indigenous probiotics

To minimize or to limit the use of antibiotics in aquaculture, the use of bacteriophages, vaccines, probiotics, prebiotics and recently the application of poly- β -hydroxybutyrate (PHB) and quorum sensing disruption have been developed and tested. The protective effects

of *Bacillus* sp. JL47 containing different levels of amorphous PHB was examined using gnotobiotic *Artemia*. The *Bacillus* isolate was grown to accumulate different levels of amorphous PHB (29% and 55% PHB on cell dry weight) and was fed to gnotobiotic *Artemia*

nauplii during a *Vibrio campbellii* LMG 21363 challenge test

Results showed that *Artemia* nauplii fed the *Bacillus* sp. JL47 containing 55% PHB attained a significantly higher survival than those *Artemia* fed the *Bacillus* sp. JL47

containing 29% PHB. Moreover, a complete protection against pathogenic *V. campbellii* was observed in *Artemia* fed the *Bacillus* sp. JL47 containing 55% PHB. The data suggest that, the protective effects of *Bacillus* sp. JL47 is superior when it contains higher amount of amorphous PHB and that the amorphous PHB is suggested to be a main determinant in the protective effect of the *Bacillus* sp. JL47.

In *P. monodon* challenged with *V. parahaemolyticus* 1213 strain, the survival was highest (76.25%) in those shrimps fed formulated diet supplemented with 1 g *Bacillus* sp. JL47 kg⁻¹, followed by shrimps fed the 0.5 g kg⁻¹ (67.5%). Shrimps fed the formulated diet containing 2 g kg⁻¹ attained only a survival of 36.25% while the lowest survival was observed in shrimps fed the control diet (without *Bacillus* sp.

JL47 supplementation; 28.75%). The non-challenged shrimps (control) attained a survival of 92.5%. The data suggests that the addition of amorphous PHB-accumulating *Bacillus* sp. JL47 can protect the shrimp against AHPND caused by *V. parahaemolyticus* 1213 strain. The suggested dose of supplementing *Bacillus* sp. JL47 in the feed is at 0.5 to 1 g bacterial weight kg⁻¹ feed.

Application of diagnostic tools for biosecurity

To determine the microbial quality of oysters (*Crassostrea irredalet*) grown in Capiz province in the Philippines, major oyster production sites located along the coastal villages of Roxas City, Ivisan and Pan-ay were investigated for fecal coliform count, *Escherichia coli* count, *Vibrio parahaemolyticus* count, and presence of *V. cholerae* and *Salmonella*, in the rearing water and oysters' meat, respectively. Oysters are filter feeders and can concentrate bacteria from surrounding seawater in their digestive system. The presence of heavy metals in the oyster meat was also monitored. Relaying stations were also monitored for their suitability, in terms of fecal coliform count, to provide for the need to relay or depurate oysters.

The monthly coliform count in the water samples collected from all sampling stations were generally high (≤ 540 MPN/100 ml) regardless of the sampling period (wet or dry season). Similarly, the monthly *E. coli* count in oysters' meat and intervalvular fluid were typically high (330~24,000 MPN/100 g) particularly during the warm dry months of the year. *V. parahaemolyticus* count quantified in oysters' meat samples examined was <3.0 MPN/g which is within the acceptable limit set by the Singapore Guideline (<100 MPN/g). Results for cadmium, chromium, lead, and mercury were below (nil) the limit of detection for all sampling sites. *V. cholerae* was not detected in any of the oyster samples examined.

All the oyster culture sites examined belong to Class C category of the EU Shellfish Area Harvesting Classification, indicating that oysters harvested from these areas are still safe for human consumption provided that they undergo proper relaying and depuration procedures or subjected to an approved method of cooking.

Relaying oysters in an approved area in Cabugao Bay, Ivisan was likewise attempted. As a result, *E. coli* count in contaminated oysters significantly dropped from 24,000 MPN/ 100g to ≤ 20 MPN/ 100g after 2 weeks of relaying, suggesting the practicality of this technique in rendering raw oysters safe for human consumption.

Prevention and mitigation of diseases in mangrove crab

Because white spot syndrome virus (WSSV) persistently causes mortality in mangrove crab in the grow-out phase, indicators responsible for disease occurrence or outbreak in cultured mangrove crabs are currently being investigated. Man-

grove crab mortality due to WSSV infection could be due to the viral load and environmental conditions such as low water temperature. Also, WSSV might be present in the pond soil and water, and may serve as vehicle for infection. Thus, to ad-

dress these concerns, the threshold levels for WSSV in the water, soil, and system of mangrove crab that may result in infection and mortality or outbreak are currently being examined in vitro and in vivo.

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.



Abalone shelter. A PVC pipe shelter was demonstrated to promote the best growth of abalone both in a tank and a reef flat.

Develop and promote efficient and suitable environment-friendly culture systems

To develop and promote efficient and suitable environment-friendly culture systems, farming protocols for several aquatic commodities were investigated.

Oyster

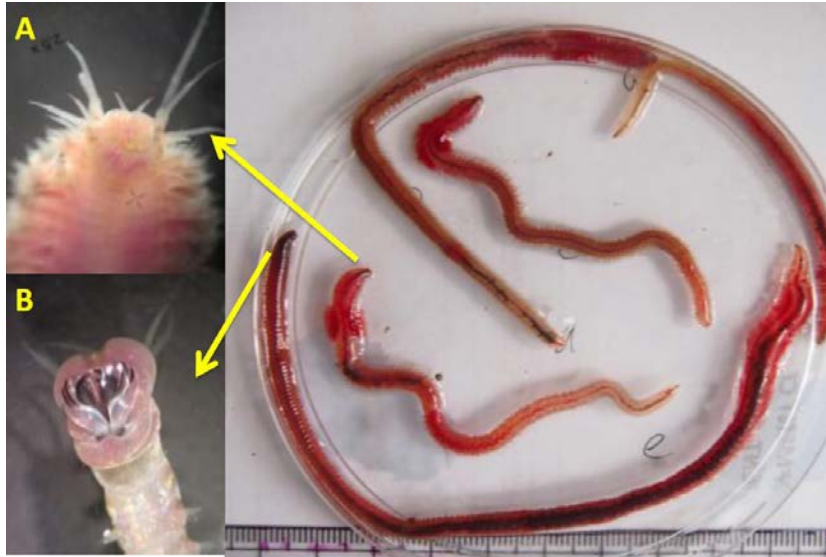
Being filter feeders with no need for artificial feeding, oysters are grown in farms with a relatively low impact on the environment. For the oyster, *Crassostrea iredalei*, the final phase of a project to refine its grow-out established that grow-out in a brackishwater environment is best compared to sites which are mostly freshwater or mostly marine. Brackishwater sites allow for the best growths and survival rates. Meanwhile, wild oyster spats grew significantly larger (87.1 mm shell length) than hatchery-bred spats (81.3 mm).

Abalone

Abalone are mollusks which graze on marine algae and seaweeds. They can be grown with hardly any negative effect on the environment. An efficient culture system was established for abalone, *Haliotis asinina*. It was found that abalone are best cultured in PVC pipe shelters, whether in a tank or in a reef flat. In both culture environments, abalone performed best at a stocking density of 200 pcs/m².

Sandfish

Pond culture of the sandfish *Holothuria scabra* in the Philippines remains to be a challenge because of several factors including the brackishwater salinity, muddy-silty substrates, shallow ponds, and unstable weather conditions that limits the culture duration.



Polychaete samples harvested after 90 days from a katsa cage installed in brackish-water pond: A. Unidentified species; B. *Marphysa mossambica*.

A project evaluation workshop was held in Concepcion, Iloilo Province, Philippines in March 2017. Stakeholder groups from the local government, academe and community gave high project performance ratings for “Environmental improvement” (8.0 to 9.0 out of 10). Workshop recommendations include (1) Strengthen law enforcement and support from LGU; (2) Further IEC activities to all stakeholders; (3) Increase and enhance the capacity of a local fisheries college to operate its hatchery; and (4) Consider other sites for establishment/expansion of sea ranch areas and/or nurseries.

Polychaetes

The culture of the marine polychaete worm *Marphysa mossambica* is being studied as it is an important food for crustacean broodstock such as mangrove crabs.

Modular cage culture techniques developed in tanks are still being verified using cages in brackish-water ponds. An indoor nursery experiment was also conducted to compare the survival and growth of polychaetes at different stocking densities. Experiments toward the production of *M. mossambica* in ponds using straight-run culture method is still ongoing.

Giant freshwater prawn

Biofloc Technology (BFT) is considered an environment-friendly, efficient system to produce aquaculture products since nutrients could continuously be recycled and reused. BFT was evaluated for suitability to culture giant freshwater prawn, *Macrobrachium rosenbergii*, across three stocking densities of 30, 40 and 60 prawns per 1-ton tank. After 6 months of culture, no significant differences in weight

and growth rates was observed among the three stocking densities tested. However, survival was highest at the lowest stocking density and lowest at the highest stocking density. FCR was poor (3.23) and lowest at 60 prawns/m², but there was no statistically significant difference in FCR between the 30 and 40 prawns/m² treatments at 2.03 and 2.15, respectively.

The multiphase strategy for the grow-out culture of giant freshwater prawn was evaluated if it could significantly improve production in a cage culture system. At the second month, significant difference in mean weight of prawns was already apparent with bigger prawns in the lowest stocking density. This trend of inverse relationship between weight and stocking density continued to be observed up to the fourth month with no significant difference in the survival of the prawns.

Seaweed

To demonstrate the technology to produce the seaweed *Kappaphycus alvarezii*, a two-day on-site training for seaweed farmers from Batbatan Island, Culasi, Antique Province, Philippines was conducted last 21-22 December 2016. Trainees were composed of 30 seaweed farmers. Topics on grow-out culture, common diseases, and updates on *Kappaphycus* culture were discussed in lectures and in an open forum. An on-site visit to Batbatan Island was also done wherein 200 pcs of seaweed plantlets were planted at Sitio Bunlao on two 10-m culture lines while water parameters were also monitored.



Biofloc setup for culture of giant freshwater prawn in 1-ton fiberglass tanks



Onsite visit of trainees on seaweed farming to Batbatan Island in Antique

Adapting to Climate Change

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



Poor quality eggs. Mangrove crab breeder with eggs that failed to spawn. Observations suggest that breeders failed to spawn during seasons of elevated temperature.

A change in global climate is projected to impact broadly across ecosystems increasing the pressure on livelihood and food supply chains, including the fisheries and aquaculture sectors. In particular, the sustainability of aquaculture will be further challenged since the effect of these climatic changes on farmed organisms is largely unknown. Increased sea surface temperatures are expected to affect reproduction and may lead to the reproductive failure of aquatic species.

Observations in the mangrove crab (*Scylla serrata*) hatchery of AQD suggest that broodstock have failed to spawn during seasons of elevated temperature. As for the larvae, the Z1 stage was observed to achieve the highest survival at 31°C. Meanwhile, older larval stages (Z2 to Z5) achieve better survival in ambient temperature (28-29°C) and have the lowest survival when reared at 33°C. Overall, observations suggest that Z1 is more tolerant to elevated temperatures while Z3 and Z4 are more sensitive to higher temperatures.

This correlates with previous findings on the siganid (*Siganus guttatus*) wherein reduced spawning was observed and hatching did not occur at an elevated temperature (33°C) and was very low under a diurnal temperature variation (31-33°C). Disrupted reproduction and decreased maturation rates were also earlier observed among captive shrimp and abalone (*Haliotis asinina*). Female abalone breeders died after 45 days at 33°C while only 10% of the males survived until day 60. Gonads of the said breeders also regressed. Meanwhile, 50% of abalone breeders survived at 31°C and ambient temperature resulted in 80% survival.



FAO-APFIC regional consultation on climate change in Bangkok where SEAFDEC/AQD initiatives were presented

Along with increasing sea surface temperatures, climate change is also expected to lead to ocean acidification because of the increased concentration of carbon dioxide in the atmosphere. Noting that the average ocean pH is now at 8.1, rotifer production in AQD appears to be affected by a lower pH. Rotifer population growth was significantly higher at 33°C and 20 ppt (day 6 of culture = 367-396 ind/ml), and lower at pH 7.5. The size of rotifers was not significantly different among treatments (87-200µm) and no abnormality in swimming or morphology was observed in all treatments. The same observations were made for the copepod *Pseudodiaptomus annandalei* where survival was lower in low pH (7.5) and high salinity (38 ppt). In another copepod, *Acartia tsuensis*, survival was likewise low in low salinity (20 ppt) and low pH (7.5).

A study on the resiliency of *Gracilariopsis heteroclada* will soon determine the range of temperature, salinity and pH levels where the seaweed can thrive.

All training courses offered by AQD have included a lecture on the impacts of climate change on aquaculture and strategies towards resiliency. The AQD Library is continuously compiling relevant updates and new information about the effects of climate change to aquaculture for easy access to interested stakeholders.

AQD supported and participated in the series of workshops on Climate Resilient Aquaculture Operations organized by the Bureau of Fisheries and Aquatic Resources. The Department also provided expertise during a National Review and Calibration of Climate Change R&D Program of the Philippine Government September 2017. Likewise, AQD attended the FAO Regional Consultation on Climate Resilient Fisheries and Aquaculture in the Asia-Pacific Region in November wherein the activities under the climate change program of the Department was presented.

Meeting Social & Economic Challenges

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



Abalone stocking. Hatchery-reared abalone juveniles were released off the island of Molocaboc Diut, upon the request of fisherfolk who hope to replicate the success of SEAFDEC/AQD's Community-Based Resource Enhancement project in the neighboring Molocaboc Dacu.

Collaborative R&D in aquaculture

Milkfish (*Chanos chanos*) is the most consumed fish and common protein source in the Philippines. Mariculture of milkfish is also the way to go to meet fish food requirements in the Philippines and other Southeast Asian countries.

To address the emerging nutrification problem in milkfish production areas around the Philippines, grow-out trials have been on-going to evaluate the application of Integrated Multi-Trophic Aquaculture (IMTA) in milkfish culture. Hatchery-reared milkfish seeds at stocking density ranging from 23-25 fingerlings per m² were stocked in two mariculture pens (156 m² average size) along with filter-feeding hatchery-reared sandfish (*Holothuria scabra*) juveniles and nutrient-absorbing seaweeds *Kappaphycus* sp. plantlets likewise produced at SEAFDEC/AQD.

Goals are being addressed by involving the participation of local fisherfolk members of the Pandaraonan Unified Association and the local government. Results from four culture runs showed production cost could be recovered, although constrained by high fingerling cost, feed and other input shipment cost to the culture site and poaching. Also, sandfish and seaweeds in IMTA system were not sustained due to predation and diseases.

Socioeconomic strategies were applied through value-adding options to overcome high input cost and to compensate for the lack of sandfish and seaweeds harvest. Overall, the collaborative R&D activities such as the application of IMTA in milkfish mariculture successful-

ly improved aquaculture skills by teaching fisherfolk to grow economically important fish and seaweeds. Fisherfolks also learned entrepreneurial and postharvest skills by selling their milkfish harvest, training women in the communi-

ty to debone and prepare milkfish dishes. Cooked milkfish in oil were fed to school children to encourage fish consumption to improve nutritional condition. These IMTA social and environmental experiments are being co-funded and imple-



Value-adding of milkfish harvest from IMTA experiments was highly appreciated by women in Barangay Pandaraonan



The Workshop on Management of Community-Based Aquaculture Projects participated by fisherfolks, women and local government officials of Barangay Pandaraonan, Nueva Valencia, Guimaras

mented together with a research fellow from the Japan International Research Center for Agricultural Sciences (JIRCAS).

Collaborative R&D in aquaculture are also being implemented through two Community-Based Resource Enhancement (CBRE) projects that use hatchery-reared seeds for stock enhancement in depleted fisheries. A CBRE project involving hatchery-reared abalone, (*Haliotis asinina*), and sandfish is ongoing in Sagay Marine Reserve in Negros Occidental funded by Government of Japan-Trust Fund (GOJ-TF).

The CBRE project in Sagay has demonstrated that hatchery-reared seeds released in suitable protected sites can help rebuild depleted coastal resources, supplement livelihood, and contribute to improving the supply of abalone in markets. Fisherfolk in Sagay benefited from the harvest of spill-overs from released abalone and sandfish in the CBRE site while the local government unit and fisherfolk associations continued to manage the project.

Moreover, the project participated in the Sustainable Seafood Week campaign of high-end gourmet establishments that aims to improve the health of the oceans by sourcing seafood products from more sustainable fisheries and aquaculture.

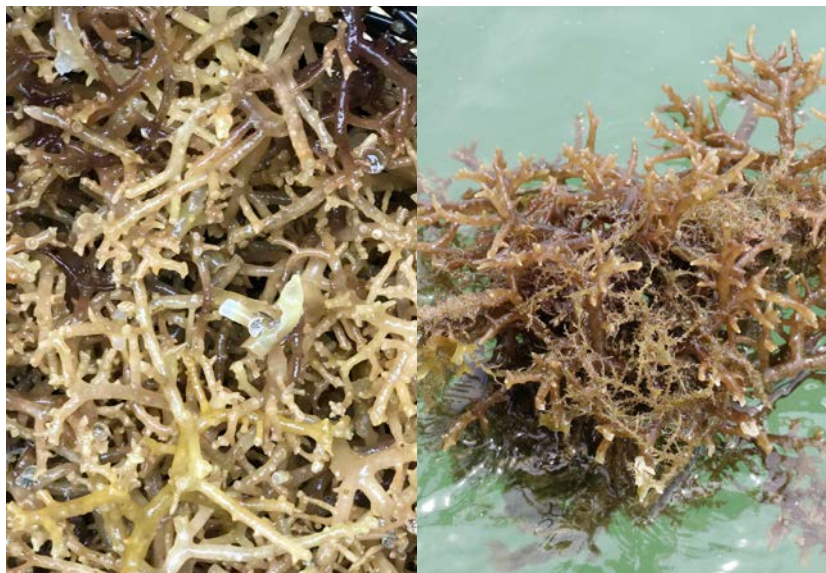
Another CBRE of hatchery-reared tiger shrimp *Penaeus monodon* in New Washington Estuary (NWE) in Aklan province funded by Research Institute for Humanity and Nature (RIHN) in Japan was also concluded recently. Released tiger shrimp juveniles grew to >100-g marketable size as monitored in

buying fish station in the fishing community. However, implementation of existing fishing gear regulations should be addressed together with local government and fisherfolks as fine mesh nets entrapped the released tiger shrimp juveniles.

These indicate the need for improving governance to support stock enhancement and ensure economic benefits for fishery stakeholders. A project evaluation workshop was conducted with stakeholders to improve future strategies.



AQD participated in the Sustainable Seafood Week held in Manila to promote the sourcing of seafood from sustainable fisheries and aquaculture



Prevalence of ice-ice disease (left) and epiphytes (right) are seen whole-year and its emergence are uncontrollable during summer season from March to May

Address emerging issues on the impacts of climate change and global trade

AQD funded a study on the “Economic benefits and losses of seaweed farmers in Guimaras, Philippines” due to some climate change indicators. The small-scale seaweed farming in Barangay Pano-bolon, Nueva Valencia in Guimaras

province was affected by lack of planting materials and diseases. High daily temperature variation recorded in January 2017 (10.1°C) coincided with ice-ice disease and slow growth reported by seaweed farmers. The study will continue

and complete the time-series data on climate change-related indicators such as temperature, salinity, seaweeds harvest and monitoring diseases which will be done together with the local farmers in the fishing village.

Multi-agency collaboration and sharing of information

The program established collaboration and linkages with the local government and fisherfolk association in areas where program studies are being conducted. The tri-party collaboration between organized fisherfolk, the local government and SEAFDEC/AQD successfully demonstrated, promoted and achieved social and economic objectives for the IMTA in Guimaras and CBRE project sites in Negros Occidental and Aklan provinces. Multi-agency collaboration initiated the replication of CBRE in more sites in Sagay and other potential remote coastal communities in Camarines Sur province through a local state university.



AQD staff with local fisherfolk of Molocaboc Diut, also comprising the inhabited island within the Sagay Marine Reserve in the Philippines, released hatchery-reared juveniles in the CBRE replicate site which they will protect and monitor

Sustainable Aquaculture & Resource Enhancement

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



Seahorses conservation campaign. Artworks illustrate the importance of protecting the natural habitat of seahorses. The artists are students (inset) in the coastal community where the resource enhancement project is located.

Fish Health Management

Develop and accelerate rapid and effective fish and shrimp health management

Viral and bacterial diseases have caused major constraints in shrimp farming in most Asian countries and in the world. Early detection of these devastating pathogens is the most efficient response to be able to implement immediate and appropriate interventions for the control of the spread of infection.

This study aims to determine the threshold infection levels (viral DNA/RNA copies in an organism that can result to an infection) for WSSV and *Vibrio parahaemolyticus* (VP_{AHPND}). Knowing these will enable the farmers to strictly monitor the health status of shrimp so that early and effective intervention strategies can be implemented. Also, the known threshold levels for the pathogens will serve as a reference in the regular monitoring and diagnostic schemes in the farm level, if it is still safe or dangerous.

Standard curve has been established using WSSV plasmid. Preliminary infection experiments to determine the concentration of viral inoculum that killed 50% of injected shrimp (LD₅₀) were conducted for the 3 weight ranges (3.81, 7.42 and 16.83 g) which showed that LD₅₀ at viral dilution of 10⁻⁶ were achieved faster in smaller weight range (9 days for ABW 3.81 g) compared to bigger weight range (10 days for ABW 7.42 g). LD₅₀ for ABW 16.83 g was achieved with lower viral dilution of 10⁻⁵ at 9 days. All the mortalities were found to be WSSV one-step positive.

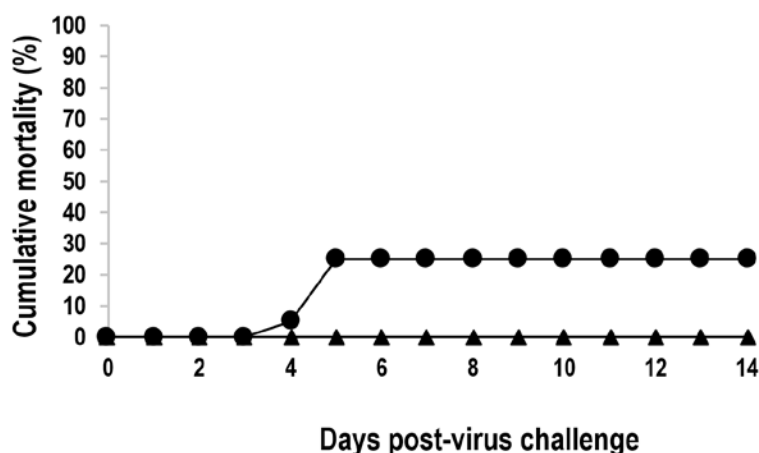
Timecourse experiment was subsequently conducted. Mortality for ABW 3.81 g has started at the range of 1.6x10⁹ to 3.3x10⁹ copies/g, 195 h post infection (pi). The range for the survivors was from 3.3x10⁶ to 4.1x10⁶ copies/g, 231 h pi. Mortality for ABW 7.42 g has started at the range of 3.7x10⁹ to 5.1x10⁹ copies/g, 231 h pi. The range for the survivors was from 6.3x10⁶ to 8.9x10⁶ copies/g, 264 h pi. Mortality for ABW 16.83 g has started at the range of 1.2x10⁹ to 4.6x10⁹ copies/g, 162 h pi. The range for the survivors was from 6.8x10⁶ to 8.8x10⁶ copies/g, 219 h pi.

Enhance efficacy of vaccine treatment in tropical cultured species

Viral nervous necrosis (VNN) caused by nervous necrosis virus (NNV), a piscine betanodavirus, is a destructive disease that induces

neuropathological abnormalities in maricultured fishes generally at the larval and juvenile stages. The objective of this study is to develop and adopt methods that would enhance the efficacy of the present NNV vaccines through the use of immunoadjuvants and other substances that promote the activation of antiviral responses in marine fish. A practical method to deliver the vaccine to fish is expected to be developed to prevent unwarranted outbreaks of VNN in hatcheries and grow-out culture systems.

The field efficacy of the inactivated nervous necrosis virus (NNV) vaccine in orange-spotted grouper (*Epinephelus coioides*) reared in net-cages in earthen pond was investigated. Seroneutralization assay conducted on the sera of vaccinated fish revealed the presence of neutralizing antibody titers from day 30 to day 150 with the highest titer observed at day 60 post-vaccination.



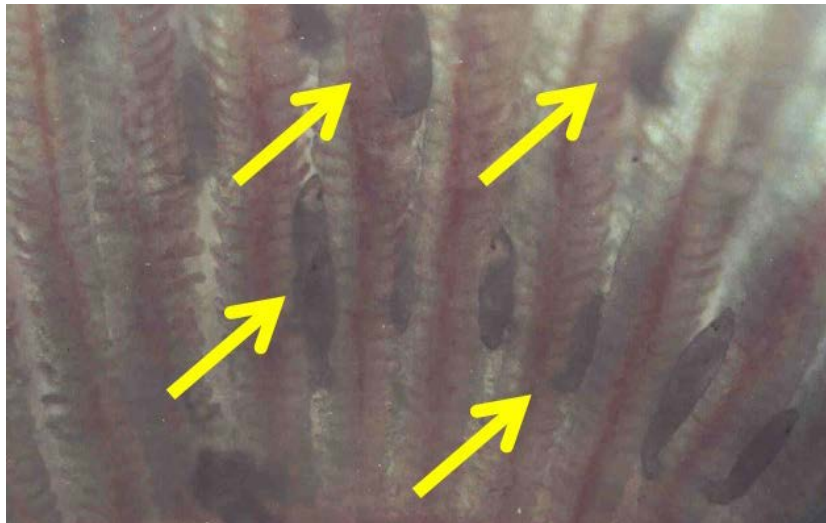
Cumulative mortalities of unvaccinated (●) and vaccinated (▲) orange-spotted grouper (*Epinephelus coioides*) juveniles intramuscularly injected with nervous necrosis virus

Nil and 25% mortality were obtained in both vaccinated and unvaccinated fish, respectively, when challenged with NNV through intramuscular injection. Additionally, NNV-challenge of day 120 vaccinated and control fish likewise resulted in nil mortality, suggesting an age or weight dependent susceptibility to NNV. Taken together, current data suggest that single vaccination with inactivated NNV vaccine could mount and confer respectively the production of protective antibodies and concomitant protection against VNN in groupers especially during the early phase of grow-out culture in earthen ponds when these fish species are highly susceptible to the disease.

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

In shrimp aquaculture, a safe, effective, and inexpensive antiviral treatment is required to limit the impact of WSSV and other shrimp viruses. RNAi is a new technology that is based on gene silencing. The antiviral effect of RNAi is based on silencing a viral or host gene that is primarily involved in viral pathogenesis. The main constraint of RNAi as an antiviral agent is production cost and a practical method of delivery.

dsRNA was produced using a low-cost bacterially expressed dsRNA production method. The efficacy of dsRNA was tested in several challenge experiments using various dsRNA doses, different



Parasites (*Pseudorhabdosynochus lantauensis*) in the gills of grouper

frequency of dsRNA administration, and inclusion of heterologous dsRNA to test the specificity of gene silencing. The best treatment was determined to be a dose of 20 μg /shrimp administered 4 times over 28 days (2 times before and 2 times after challenge (total = 80 μg /shrimp). Furthermore, the silencing was found to be specific to VP28 dsRNA. Oral delivery using different ratios of dsRNA to rVP28 entrapped in microparticle carriers will be tested by challenge experiments in tanks.

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

This study aims to develop practical strategies that could be adopted by farmers to address the pressing problem on mass mortalities of net-caged and pond-reared fishes attributed to persistent and emerging fish parasites. This study examines the anti-parasitic effect garlic (*Allium sativum*) in the form of allicin

powder against monogenean parasites (*Pseudorhabdosynochus lantauensis*) infecting groupers (*Epinephelus coioides*).

Acute toxicity bioassays to determine the 96 h LC_{50} value of allicin powder were carried out in static systems. Results showed that the median lethal concentration (LC_{50}) of allicin powder to grouper for 24, 48, 72 and 96 h of exposure are 172.37, 168.52, 134.90 and 73.63 ppm respectively. Oral treatments using allicin powder-supplemented diet (0.10%, 0.50%, and 1.0%) and a control diet without allicin were tested on groupers infected with *P. lantauensis* for 14 days. Results showed that groupers fed with allicin powder supplemented diets showed reduced prevalence and mean intensity of monogenean parasites as compared to the control. Histological examination showed no pathological changes in the liver, intestine and kidneys of the fish.

Also, hematological changes were compared in both *Trichodina* sp.-infected and uninfected tilapia (*Oreo-*

chromis niloticus). Results showed that hematocrit, hemoglobin and red blood cell count were lower in infected fish than in healthy individuals. In contrast, white blood cell count was higher in infected fish compared to non-infected fish. Acute toxicity bioassays to determine the 96 h LC₅₀ value of allicin powder in tilapia were carried out in static systems. The LC₅₀ values of garlic extract for 24, 48, 72 and 96 hours were 398.1, 360.7, 316.21 and 208.95 ppm respectively.

Epidemiology of EMS/AHPND

Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Disease (AHPND) is a shrimp disease caused by the *Vibrio parahaemolyticus* affecting most Southeast Asian Countries. This activity aims to develop protective measures, in cooperation with farmers and hatchery operators, based on the causative agents together with identification of risk and protective factors.

Results of the pathogenicity tests indicate that the threshold level of VP_{AHPND} bacteria in the environment that shrimp may overcome is 10⁶ cfu/ml. Furthermore, exposure to 10⁷cfu/ml VP_{AHPND} bacteria may cause significant mortality in *P. monodon* postlarvae. High temperature (35°C), high (28ppt) and low (10 ppt) salinities are other possible factors that may increase the risk of mortality due to VP_{AHPND} infection.

Use of greenwater that has been stocked with siganid (*Siganus* spp.) for not less than 2 weeks might provide some protection against the disease as shown by less *V. parahaemolyticus* detected in the hepatopancreas of shrimp. Use of siganid water to culture

shrimp was further shown to improve shrimp growth and survival. Use of brown mussel (*Perna perna*) may also improve shrimp survival but needs further investigation.

Technology extension and demonstration

On-site evaluation of the aquaculture practices in selected developing countries was conducted to assess the compounding factors that trigger persistent diseases caused by parasites, bacteria and viruses in freshwater fishes. Further, to boost the capability of fish health personnel, basic on-site training courses on fish bacteriology and parasitology were also undertaken.

An on-site training course “Health Management of Parasitic Diseases of Freshwater Fishes” was conducted from 6 to 10 December 2016 at the Fish Health Laboratory of the Marine Research and Development Center, Sihanoukville, Cambodia, as per request of its country representative during the SEAFDEC council meeting. Eleven staff from

Cambodia’s different aquaculture agencies participated in the training.

As per Lao PDR’s request, a similar on-site training course was conducted on 20-24 November 2017 at Namxoung Aquaculture and Development Center, Namxoung, Lao PDR. A total of 15 participants from different institutions in Lao PDR participated. Lectures highlighted the major bacterial and parasitic diseases currently affecting cultured freshwater fishes in the region. Moreover, hands-on exercises including fish necropsy, quantitative determination of parasite load in the gills and skin of fish and subsequent identification of the parasite present in the fishes examined were successfully carried out. Additionally, an update on tilapia lake virus infection, an emerging and pressing problem currently besetting the tilapia aquaculture industry in Asia was presented. On the last day of the training, a field trip to a farm was conducted to observe the actual pond culture practices.



Practical session of the on-site training on Health Management of Parasitic Diseases of Freshwater Fishes held in Lao PDR

Sustainable Aquaculture Project

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

The expansion of the tilapia industry has intensified the demand for fishmeal as one of the primary protein sources in aquaculture feeds. Due to increasing costs of fishmeal, various fishmeal replacers for tilapia, including agro-industrial wastes and by-products, are being explored and information on their nutritive value and inclusion level tested to ease dependence on fishmeal. Mango peel silage, soybean curd residues and citrus by-products were evaluated for their potential as fish meal substitute.

Substitution of fishmeal with mango peel silage up to 500 g kg⁻¹ diet increased fry production but resulted in slightly reduced weight gain of tilapia breeders over the 51-week period. Soybean curd residues could replace up to 300 g kg⁻¹

diet of fishmeal protein in tilapia fingerlings diets. Supplementation of citrus by-products such as citrus peel and citrus pulp at 10 g kg⁻¹ diet also enhanced growth and feed utilization of tilapia fingerlings.

Responsible aquaculture through aquasilviculture

As diseases continue to devastate the shrimp industry, one culture system that has the potential to abate disease occurrence and improve shrimp survival is aquasilviculture – the culture of aquatic organism with mangroves inside the pond (mixed system) or in the receiving environment. This study aims to determine the time required for a mangrove habitat to remove nutrients from shrimp farm effluents. Preliminary results showed that ammonia, phosphate, chlorophyll a and total suspended solids were fluctuating but generally lower in water drained into a mangrove habitat compared to an area without mangroves. Ammo-

nia and phosphate were removed from the pond effluent drained into a mangrove habitat, 3-5 days after draining. Furthermore, mangrove to pond area ratio does not seem to affect the efficiency of the mangrove habitat in nutrient removal.

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

Sandfish (*Holothuria scabra*) are detritus feeders in intertidal flats and reef areas that help aerate marine sediments and recycle nutrients necessary for maintaining marine ecosystems. Abalone (*Haliotis asinina*) are gastropods that feed on encrusting algae and micro-particulates in coralline areas. Households in coastal and island communities earn income from selling these high-value export commodities, however this has also led to the overexploitation of these species.

The community-based integrated production of abalone and sandfish through culture, sea ranching and stock enhancement has been promoted for low-income households in Molocaboc Island within the Sagay Marine Reserve in Negros Occidental, Philippines. This project aims to maintain the health of the intertidal and reef environment through production systems that use hatchery-bred seeds produced from local broodstock and grown with natural food while providing sustainable sources of income for coastal dwellers in remote island communities.

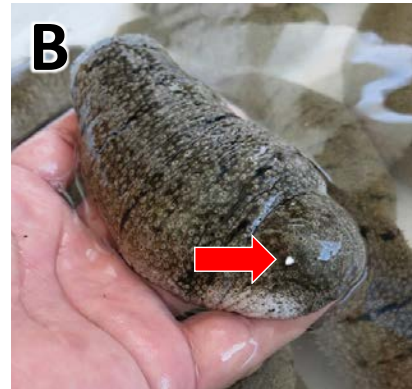
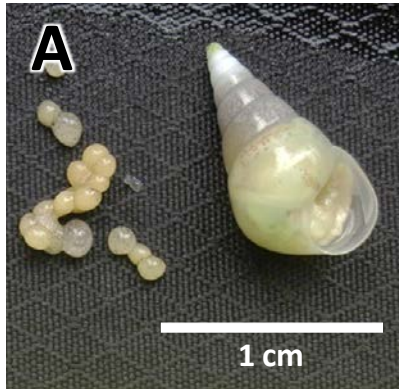


Mangroves inside a fishpond are seen to aid in the removal of excess nutrients from aquaculture effluents

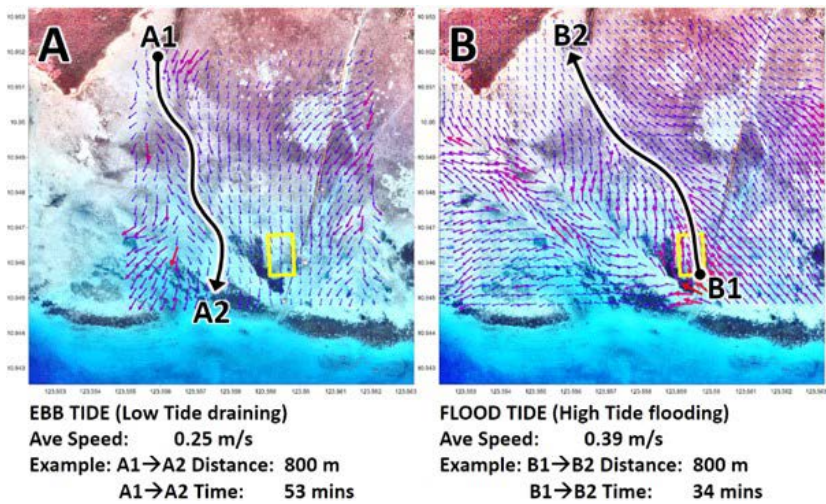
From August 2015, locally-sourced sandfish adults from Molocaboc Island produced a total of 81,918 hatchery-reared early juveniles that were successively nursed in floating hapa nets then in conditioning pens. Of which at least 10.6 % grew to >20 g and were released in a sea ranch in Molocaboc Dacu by November 2017. The density of sandfish within the sea ranch has increased from less than 3 individuals/hectare in 2015 to 128 individuals/hectare in 2017, which indicate that sandfish sea ranching can be a helpful intervention to mitigate further loss of this commercial species.

New challenges also arose in 2017 as a few large sandfish (>100 g) were observed to have caught some endo-parasitic sea snail. Initial lab studies showed that the gastropod parasite does not adversely affect growth and reproductive capacity of the sandfish host. Further monitoring at the ranch revealed that they do not infect other sea cucumber species and the degree of infection is well below the normal levels of <10 % and can be easily managed by removal of infected individuals. Experts identified the parasite to belong to the genus *Prostilifer* under the Family Eulimidae, but the species is yet to be determined.

Tidal current was monitored to determine the water flow within and around the Molocaboc sea ranch site and to show potential dispersal direction of planktonic larvae of abalone and sandfish. Tidal current at the Molocaboc sea ranch site is generally low. The persistent direction of currents during flood tide may lead planktonic larvae of abalone and sandfish to thick covers of seagrasses which are known to be



The adult female and egg sacs (A) of the gastropod endo-parasite of sandfish found at Molocaboc. Infection occurs at the anal or posterior portion of the sandfish host where only the tip of its shell is visible (B, red arrow)



Tidal water current profile at the Molocaboc sea ranch site (yellow rectangle) during ebbing tide (A) and flooding tide (B) on 20 September 2017

good settlement substrates particularly for sandfish larvae.

Construction of a solar and fuel-powered abalone hatchery in Molocaboc Dacu began in December. This is expected to sustain the supply of juveniles for future releases.

Promotion of resource enhancement of seahorses

Seahorses (*Hippocampus* spp.) are highly exploited for their high price.

They were among the first marine fishes of commercial importance to be listed in the International Union for Conservation of Nature and all seahorses are listed in the Convention on International Trade of Endangered Species of Wild Fauna and Flora Appendix II. This study aims to promote resource enhancement of seahorses primarily by developing appropriate release and monitoring strategies of seahorses and to promote the involvement of the community in the management of the natural resources.

Transport trials on three size groups of juvenile seahorses (5, 6, and 7 cm stretched height) showed optimum stocking density of 3 ind/L for all size groups at 10 to 12 h transport duration.

Monitoring of seahorses in Molocaboc Island showed increase of natural stocks in 2016-2017 compared to previous years (2012-2015). This suggests that natural population of seahorse may recover through management of the natural resources, particularly by minimizing human disturbance on their habitat and non-collection of seahorses. Natural food such as mysids and copepods are abundant in the area, which may explain the all year round presence of sexually mature seahorses. However, the average number of seahorses from 2017 (30 ind or 0.0025 m⁻²) showed a much lower density than the reported (0.02 m⁻²) low density of seahorse in Bohol province. Release of hatchery-reared juveniles may help to enhance recovery of the seahorse population and density.

Fisherfolk organization members participated in the hands-on training on monitoring of seahorses. Practical lectures on seahorse biology and handling of live seahorses were conducted for divers during seahorse sampling. The annual information, education and communication campaign this year was held on 22-23 November 2017 wherein lectures on seahorse biology and resource management was given to locals, particularly the elementary and secondary students of Molocaboc Island. A Draw and Tell contest was conducted with the theme “My role in the promotion of seahorse as a natural resource in my community.”



Trainees learn to determine the sex of freshwater prawn broodstock during the *International Training Course on Community-based Freshwater Aquaculture for Remote Areas of Southeast Asia*

Capacity building programs

As the aquaculture of high-value marine finfish species continues to develop rapidly in Southeast Asia, a training program on “Marine Fish Hatchery” will extend and demonstrate the breeding, hatchery seed production, nutrition and health management of different marine fish species.

Out of 7 total participants, 2 were supported by the Government of Japan Trust Fund (GOJ-TF), 1 each from Myanmar and Viet Nam.

Training activities included lectures, slide and video showing, while practical activities covered larval rearing, natural food culture of both phyto and zooplankton, feeding, water management, fish health management, induced spawning, egg collection and harvesting and field visits. Trainees had hands-on larval rearing of all the marine fish species at the fish hatchery namely, milkfish, sea-

bass, siganid, grouper, snapper and pompano.

Another training with a focus on the promotion of community-based freshwater aquaculture for remote rural areas of Southeast Asia was organized to promote and transfer freshwater aquaculture technologies applicable to rural areas. The “International Training Course on Community-based Freshwater Aquaculture for Remote Areas of Southeast Asia” was conducted 21-30 November 2017 at the Binangonan Freshwater Station.

Five of the 7 participants (1 from Cambodia, 1 from Myanmar and 3 from the Philippines) were supported by the GOJ-TF. Participants were trained in freshwater fish culture technologies and social preparation methods for rural aquaculture development. The training concluded with the trainees’ presentation of a project proposal for a rural community.

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.



Marine fish hatchery training. A trainee holding an anaesthetized grouper breeder during one of the practical sessions

Overview

A total of 385 trainees participated in the 29 training courses organized this year with 21 nationalities represented. This is up from 261 trainees in 23 training courses in 2016.

Profile of trainees revealed that 75% were private individuals, 15% identified with the academe and 10% were government personnel. Participants from the Philippines continued to dominate the trainee population this year (88%) due to

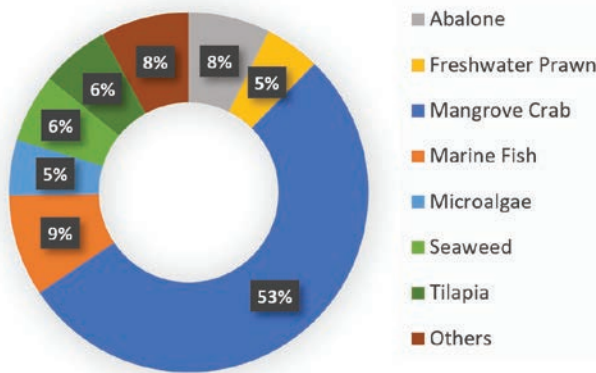
several specialized training courses sponsored by non-government organizations based in the country. Several of these specialized training courses were organized to aid fisherfolk who were affected by Typhoon Haiyan which hit the Philippines in 2013.

Mangrove crab technology drew the most interest among the commodities with 53% of commodity-based training participants, or 181 individuals, interested on various

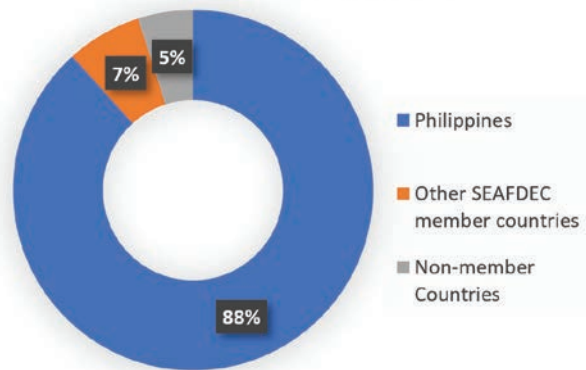
phases of mangrove crab culture. A far second and third are trainees on marine fish (9%) and abalone (8%) technologies.

Meanwhile, 307 students coming from 39 schools participated in On-the-Job Training to accomplish their respective school requirements. Also, a total of 44 individuals signed up for the Internship Program to gain experience in various AQD facilities.

Participants by commodity



Trainees by country



Trainees learn to determine the sex of freshwater prawn broodstock



Pompano breeders are anaesthetized as part of the training on *Selected Aquaculture Technologies*

Regular Training Courses

| Course, date, venue | Total participants | Countries represented by participants |
|---|--------------------|---|
| Tilapia Hatchery & Grow-out Operations 13 - 17 March (BFS, Binangonan, Rizal) | 8 | United Kingdom: 2 Philippines: 6 |
| Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery and Management 19 April - 03 May (TMS, Tigbauan, Iloilo) | 5 | Germany: 1 India: 1 Indonesia: 1 Italy: 1 Solomon Islands: 1 |
| Abalone Hatchery & Grow-out 10 - 30 May (TMS, Tigbauan, Iloilo) | 4 | Malaysia: 2 Philippines: 2 |
| Freshwater Prawn Hatchery & Grow-out Operations 15 - 19 May (BFS, Binangonan, Rizal) | 10 | Japan: 1 Lao PDR: 2 Philippines: 7 |
| Marine Fish Hatchery 20 June - 26 July (TMS, Tigbauan, Iloilo) | 7 | Malaysia: 1 Myanmar: 1 Philippines: 4 Vietnam: 1 |
| Tilapia Hatchery & Grow-out Operations (Session 2) 14 - 18 August (BFS, Binangonan, Rizal) | 10 | Philippines |
| Mangrove Crab Hatchery & Nursery Operations 14 August - 4 September (TMS, Tigbauan, Iloilo) | 16 | French Polynesia: 1 Indonesia: 1 Malaysia: 2 Philippines: 7 Singapore: 3 Thailand: 2 |
| Distance Learning Course on Principles of Health Management in Aquaculture (AquaHealth Online) 10 September - 16 December | 7 | New Caledonia: 1 Nigeria: 1 Philippines: 4 Singapore: 1 |
| Freshwater Prawn Hatchery & Grow-out Operations 11 - 15 September (BFS, Binangonan, Rizal) | 11 | Philippines |
| Mangrove Crab Nursery & Grow-out Operations 18 - 27 September (TMS, Tigbauan, Iloilo) | 18 | Philippines: 14 Singapore: 4 |
| Community-Based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia 21 - 30 November (BFS, Binangonan, Rizal) | 7 | Cambodia: 1 Myanmar: 1 Philippines: 5 |

Specialized Training Courses

| Course, date, venue | Total participants | Countries represented by participants |
|--|--------------------|---------------------------------------|
| Mangrove Crab Nursery & Grow-out Culture 31 January - 01 February (Plandico, Concepcion, Iloilo) <i>Funded by World Renew Philippines</i> | 32 | Philippines |
| Mangrove Crab Nursery & Grow-out Culture 08 - 10 February (Roxas, Oriental Mindoro) <i>Funded by RIB Reformnation/The SWAN SFS/ Tamaraw YPR/BFAR-4B</i> | 49 | Philippines |
| Seahorse Culture 26 - 28 April (TMS, Tigbauan, Iloilo) | 2 | Philippines |
| Mangrove Crab Hatchery, Nursery & Grow-out Operations 02 - 16 May (TMS, Tigbauan, Iloilo) | 3 | Philippines |
| Oyster Seed Production, Nursery & Grow-out 29 May - 03 June (TMS, Tigbauan, Iloilo) <i>Funded by ASIN, Inc.</i> | 14 | Philippines |
| Mangrove Crab Hatchery Operations 12 June - 12 July (TMS, Tigbauan, Iloilo) <i>Funded by Pangasinan State University</i> | 5 | Philippines |
| Selected Aquaculture Technologies 10 July - 10 August (TMS, Tigbauan, Iloilo) <i>Funded by National Fisheries Authority of Tanzania</i> | 2 | Tanzania |
| Seaweed Culture 26 - 28 July (TMS, Tigbauan, Iloilo; San Dionisio, Iloilo) <i>Funded by CARE-Philippines</i> | 21 | Philippines |
| Abalone Culture 26 - 28 July (TMS, Tigbauan, Iloilo; San Dionisio, Iloilo) <i>Funded by CARE-Philippines</i> | 21 | Philippines |
| Mangrove Crab Nursery & Grow-out Culture 29 July (Calatagan, Batangas) <i>Funded by Junior Chamber International - Batangas</i> | 16 | Philippines |
| Grow-out Culture of Grouper 29 - 30 August (Concepcion, Iloilo) <i>Funded by ADRA-Philippines</i> | 19 | Philippines |
| Grow-out Culture of Grouper 31 August - 01 September (Ajuy, Iloilo) <i>Funded by ADRA-Philippines</i> | 29 | Philippines |
| Milkfish Culture in Ponds 21 September - 11 October (TMS, Tigbauan, Iloilo; DBS, Dumangas, Iloilo) | 4 | Papua New Guinea: 2 Philippines: 2 |

| Course, date, venue | Total participants | Countries represented by participants |
|---|--------------------|---------------------------------------|
| Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery & Management (Session 2) 05 - 19 October (TMS, Tigbauan, Iloilo) | 6 | Madagascar: 2 Philippines: 4 |
| Use of Commercially Available Microalgae Concentrate in Hatchery Culture of Sea Cucumber (Sandfish) 23 - 30 October (TMS, Tigbauan, Iloilo) <i>Funded by ACIAR</i> | 14 | Philippines |
| Mangrove Crab Hatchery 06 - 17 November (TMS, Tigbauan, Iloilo) | 1 | India |
| Mangrove Crab Culture 28 - 29 November (Alabat, Quezon) <i>Funded by PCAARRD-DOST/SLSU-Alabat, Quezon</i> | 41 | Philippines |
| Algal Culture & Isolation 04 - 11 December (TMS, Tigbauan, Iloilo) | 3 | India |

Internship and On-the-job-training

| Course, date, venue | Total participants | Countries represented by participants |
|---|---------------------|---|
| Internship at AQD hatcheries, laboratories and stations | 44 | Philippines: 43 Foreign: 1 |
| On-the-job-trainings a requirement in academic institutions | 307 (39 schools) | Philippines: 303 Belgium: 3 Thailand: 1 |



Trainees clean oyster broodstock during a *Training Course on Oyster Seed Production, Nursery & Grow-out*



Crab breeder's carapace length being measured by a trainee during a session on mangrove crab biology

Information Dissemination & Public Awareness

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



Visit of ASEAN Ministers. A seahorse display captures the attention of ASEAN government officials who came to visit AQD's Tigbauan Main Station in March 2017.

Science Papers in Journals and Proceedings

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Presentations delivered in international and local fora

The output of the research and development activities at SEAFDEC/AQD are presented by research and information staff in numerous external conferences, sympo-

siums, forums and other meetings. Below is a non-exhaustive list of the various presentations made in non-SEAFDEC events in 2017. Tec-

no-forums were also organized by SEAFDEC/AQD and done as part of various events. These are listed on page 48.

| Event | Location | Date | Title of presentation | Authors/ Presentors |
|---|--------------------------|-------------|---|---------------------|
| Strategic Planning Workshop on Technologies for Biodiversity Use and Conservation (TechBioDive) | Makati City, Philippines | 10 Feb | Genetics and Biodiversity Research at SEAFDEC/AQD | Eguia MRR |
| 17th Annual Regional Convention and Scientific Session of the Biology Teachers Association of the Philippines, Inc. Western Visayas Chapter | Iloilo City, Philippines | 16-17 Feb | Fish Health, Nutrition, and Food Safety in Aquaculture | Pakingking RV Jr. |
| Sustainable Seafood Week | Taguig City, Philippines | 21 Feb | Aquaculture as Provider of Sustainable Seafood | Eguia MRR |
| Responsible Production and Use of Feed and Feed Ingredients for Sustainable Growth of Aquaculture in Asia-Pacific | Bangkok, Thailand | 3-9 March | Promoting cost-effective aquaculture feed made with locally available ingredients | Mamaug RE |
| International Course on Responsible Aquaculture Development for Food Security and Economic Progress | Wageningen, Netherlands | 17 March | Shrimp Culture Practices to Prevent Diseases | Tendencia EA |
| Visayas Regional Scientific Meeting | Cebu City, Philippines | 18-19 April | Dialogue: On Emerging Diseases in Shrimp Culture | Pakingking RV Jr. |

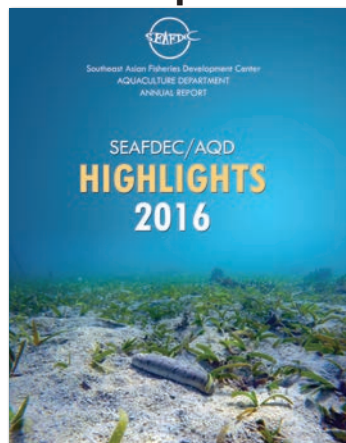
| Event | Location | Date | Title of presentation | Authors/ Presentors |
|---|--------------------------|-------------|--|---|
| The 9th China International Shrimp Industry Development Forum | Zhinjiang, China | 19-20 April | Shrimp Production, Processing, Marketing and Trade in the Philippines | Salayo ND |
| Korean Society of Fisheries and Aquatic Science Annual Fisheries Conference | Busan, Republic of Korea | 11-12 May | Seasonal gonad cycle and chemical composition of wild and hatchery-reared silver therapon <i>Leiopotherapon plumbeus</i> (Kner, 1864) (Perciformes: Terapontidae) | Aya FA, Sayco MJ, Garcia LMB, Bai SC |
| | | | Effect of fermented tuna by-product containing diets with and without Song-gang stone® on growth, immune response and disease resistance in juvenile olive flounder, <i>Paralichthys olivaceus</i> | Oncul FO, Aya FA, Seong M, Lee JH, Lee G, Han KR, Bai SC |
| Regional Workshop on the Contribution of Oceanographic Data and Information Management and Exchange to Ocean and Coastal Sustainability and SDG-14 | Tianjin, China | 16-18 May | Dissemination of Aquatic and Marine Information and Networking with Libraries – The SEAFDEC Aquaculture Department Experience | Alayon SB |
| Annual General Meeting of the National Research Council of the Philippines - Visayas Regional Cluster | Aklan, Philippines | 19 May | Science, Governance and Fisherfolk Partnership: Key to Successful Community-Based Resource Enhancement | Salayo ND, Altamirano JP |
| 18th International Congress of Comparative Endocrinology | Alberta, Canada | 4-9 June | Recombinant Follicle Stimulating Hormone-Induced Testicular Development in Immature Protogynous Grouper (<i>Epinephelus</i> sp.) | Palma P, Nocillado J, Superio J, Ayson EG, Ayson F, Bright D, Bar I, Elizur A |
| 1st ASEAN Network of Aquatic Animal Health Centers Meeting on the Implementation of Standard Operating Procedure for Responsible Movement of Live Aquatic Animals | Bangkok, Thailand | 20-21 June | The Need for a Harmonized Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia | Pakingking RV Jr. |
| World Aquaculture 2017 | Cape Town, South Africa | 26-30 June | Stock enhancement of shrimps in the Philippines and its impact on fisheries and the community | Altamirano JP, Salayo ND, Kurokura H, Fushimi H, Ishikawa S |
| | | | Understanding bio-physical variability in sea cucumber ranching sites in the Philippines | Altamirano JP, Juinio-Meñez MA, Uy W, dela Cruz M, Rodriguez BDR, Hair C, and Mills D |
| | | | Rearing performance of floating hapa bag nets for early juvenile sandfish <i>Holothoria scabra</i> (Poster) | Noran-Baylon R, Altamirano JP, Recente CP |
| Training Course on ASFA Input Methodology | Terengganu, Malaysia | 2-6 July | ASFA Input Methodology | Superio DL |
| 14th National Symposium in Marine Science | Batangas, Philippines | 13-15 July | Mitigating the Environmental Impacts of Milkfish Mariculture Through Integrated Multi-Trophic Aquaculture (IMTA): Preliminary Results | Diamante RA, Kodama M, Salayo ND, Castel RJG |
| | | | Challenges and prospects for sea cucumber pond culture in the Philippines | Altamirano JP, Noran-Baylon RD, Recente CP |

| Event | Location | Date | Title of presentation | Authors/ Presentors |
|--|----------------------------------|-----------------|--|---|
| 2018 Asia Pacific Aquaculture Conference | Kuala Lumpur, Malaysia | 24-27 July | Nutritional evaluation of distiller's dried grain with soluble (DDGS) as replacement to soybean meal in diets of milkfish, <i>Chanos chanos</i> and its effect on fish performance and intestinal morphology | Mamaug RE |
| Public Consultation Meeting on the Draft Philippine National Standards on Milkfish and Tilapia | Quezon City, Philippines | 27 July | Status of the Philippine tilapia industry | Eguia MRR |
| 7th National Symposium and Scientific Meeting of Philippine Phycological Society, Inc. | General Santos City, Philippines | 28-29 July | Production of <i>Nanochlorum</i> sp. paste using electrolytic flocculation | Franco, AV |
| DOST Science Week, Region IV-B | Romblon, Philippines | 16 Aug | Community-Based Resources Enhancement (CBRE): A Potentially Climate-Resilient Fisheries Management Strategy | Salayo ND, Altamirano JP |
| 10th Symposium on Diseases in Asian Aquaculture | Bali, Indonesia | 28 Aug - 1 Sept | Shrimp survives exposure to low <i>Vibrio parahaemolyticus</i> AHPND concentration (Poster) | Tendencia EA |
| | | | Ocular vibriosis in cage cultured snubnose pompano <i>Trachinotus blochii</i> in the Philippines (Poster) | Pakingking RV Jr. |
| 3rd International Conference on Fisheries and Aquatic Sciences | Iloilo City, Philippines | 30-31 Aug | Managing the commons: The case of community-based sea cucumber ranching in the Visayas region | Suyo JGB, Altamirano JP, dela Cruz M |
| 7th Fish and Shellfish Larviculture Symposium | Gent, Belgium | 4-7 September | Molecular cloning of phasin protein from <i>Bacillus</i> sp. JL47 and its effects on the survival of gnotobiotic <i>Artemia</i> during a <i>Vibrio campbellii</i> challenge (Poster) | Laranja JLQ, Nguyen DV, Pascual GL, Amar EC, Baruah K, De Schryver P, Bossier P |
| FishLink 2017 | Iloilo City, Philippines | 6-8 Sept | Abalone culture: a profitable option | Lebata-Ramos MJH |
| | | | Aquaculture health management: living with pathogens | dela Peña, LD |
| 7th International Oyster Symposium | Wales, United Kingdom | 11-14 Sept | Why me? Because I'm single, young and more meaty | Lebata-Ramos MJH |
| | | | Microbiological Quality of Oysters (<i>Crassostrea iredalei</i>) Produced in the Coastal Areas of Panay Island, Western Visayas, Philippines | Pakingking RV Jr. |
| FAO Regional Meeting on Agricultural Biotechnologies in Sustainable Food Systems and Nutrition in Asia-Pacific | Kuala Lumpur, Malaysia | 11-13 Sept | DNA Marker applications in the management of farmed aquatic genetic resources in the Philippines | Eguia MRR |
| Genetics for Milkfish Broodstock Management | Cebu City, Philippines | 15 Sept | Microsatellite and RAPD Markers for Milkfish Broodstock Management | Eguia MRR, Santos BS, Benjamin P, Basiao ZU |

| Event | Location | Date | Title of presentation | Authors/ Presentors |
|---|---------------------------|----------------|---|--|
| The JSFS 85th Anniversary-Commemorative International Symposium | Tokyo, Japan | 22-24 Sept | Surveillance of white spot syndrome virus (WSSV) and acute hepatopancreatic necrosis disease (AHPND) in the Philippines | Amar EC, Bilbao AD, dela Peña LD, Moquera G, Villanoche C, Saloma CP |
| | | | Development of Integrated Multi-Trophic Aquaculture (IMTA) to Mitigate the Environmental Impacts of Milkfish Mariculture: Preliminary Results | Diamante RA, Kodama M, Salayo ND, Castel RJG |
| | | | Partial replacement of fish meal for milkfish <i>Chanos chanos</i> feed using poultry by-product meal (Poster) | Sugita T, Amafe AB, Sumbing JG |
| | | | Effects of Stocking Density on Growth and Biochemical Compositions in Juvenile Milkfish, <i>Chanos chanos</i> | Gavile AB, Sumbing JG, Sugita T |
| Davao AgriTrade Fair 2017 | Davao City, Philippines | 23 Sept | Tilapia, Giant Freshwater Prawn and now, Silver Perch!: Breeding and Farming Updates | Eguia MRR |
| 8th Asian Pacific Phycological Forum | Kuala Lumpur, Malaysia | 8-13 October | Potential of local strain <i>Chlorella sorokiniana</i> paste as feed for the minute rotifer, <i>Proales similis</i> de Beauchamp in Philippine conditions | Franco AV |
| 43rd International Association of Aquatic and Marine Science Libraries and Information Centres Conference | Honolulu, Hawaii | 22-26 Oct | A Survey of the Information-seeking Behavior (ISB) of Aquatic Science Librarians in Response to a Query | Superio DL, Oliveros MGH, Palcullo VEV |
| | | | User Acceptance of IAMSLIC Digital Fisheries Library | Alayon SB, Watkins S |
| | | | Factors Associated with the Information-seeking Behavior of Filipino Scientists, Researchers and Research Staff at SEAFDEC/AQD | Superio DL |
| 3rd National Fisheries Biotechnology Symposium | Muñoz, Philippines | 14-15 November | Application and mode of action of poly-beta-hydroxybutyrate-accumulating <i>Bacillus</i> spp. as biocontrol agents in aquaculture | Laranja, JLQ |
| 7th Rizal Library International Conference | Quezon City, Philippines | 16-18 Nov | The use of social media by college students who are first-time voters in the 2016 national election | Alayon SB |
| PLAI National Congress and General Assembly | Bacolod City, Philippines | 21-24 Nov | The UN 2030 Agenda and libraries/knowledge development centers of international organizations in the Philippines | Abrigo VM, Prosperoso AM, Delos Reyes N, Fonseca NN, Zafrá AC, Arriesgado A, Alayon SB |
| JIRCAS Annual Review Meeting | Penang, Malaysia | 5-6 Dec | IMTA Socioeconomics Activities from Apr 2016 to Dec 2017 | ND Salayo, RJG Castel |
| | | | Nutritional evaluation of distiller's dried grain with soluble (DDGS) as replacement to soybean meal in diets of milkfish, <i>Chanos chanos</i> and its effect on fish performance and intestinal morphology. | RE Mamauag |

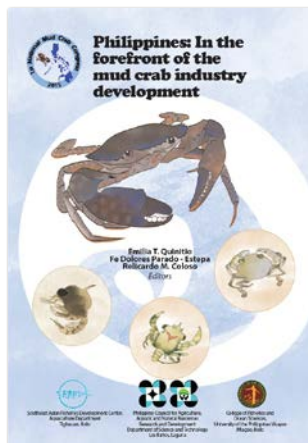
Publications

Annual Report



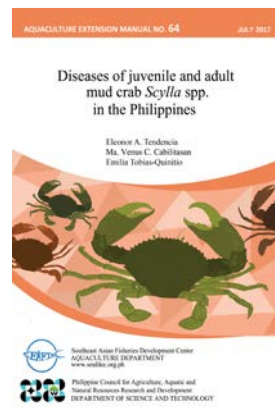
Highlights 2016 is SEAFDEC/AQD's annual report updating on its accomplishments and progress for the year 2016

Conference Proceedings



Philippines: In the forefront of the mud crab industry development is the proceedings of the 1st National Mud Crab Congress held in 2015

Extension Manual



Diseases of juvenile and adult mud crab Scylla spp. in the Philippines (AEM 64) lists and describes the viral and bacterial diseases and other abnormalities that affect mud crabs

Brochures



A series of commodity brochures on abalone, catfish, sea bass and *Kappaphycus* seaweed farming were produced. Another brochure featuring the Community-Based Resource Enhancement project in Sagay Marine Reserve was also published

Newsletter



The bi-monthly AQD Matters newsletter received a new look in 2017 and continued to update on the latest AQD developments

Internet and Media

Website and Repository

The official website (www.seafdec.org.ph) continued to be updated, improved, and integrated with social media to attract engagement. A total of 63,059 unique visitors were logged for the year with 345,060 page views. Majority of website visitors originated from English-speaking countries, primarily the Philippines. Towards making the website accessible to more stakeholders from member countries, a tool was introduced that can auto-translate the website content into the 9 other official languages of member countries.

The SEAFDEC/AQD Institutional Repository (SAIR) also continued to enhance the accessibility of the Department's scholarly and research information by making them available for free and online. SAIR continued to be updated with the latest articles with 3,106 items archived as of 2017. With the increase in the demand for information, improved indexing in search engines and more items available to search in the repository, downloads of documents continued to increase, hitting 1.3 million this year.

Library Exchange

This year, the SEAFDEC/AQD Library's exchange program sent out a total of 115 publication titles to 138 partner libraries around the world. This exchange involved 24,844 copies of SEAFDEC/AQD publications sent out.

Public Media

Information dissemination through mass media was ramped up with 17 press statements delivered by AQD contributing to

54 appearances in print and online media as well as 2 television appearances.

Business Mirror

Expert urges government to plant mangroves in abandoned fish ponds in coastal areas (10 March 2017, page A-9)

Manila Bulletin

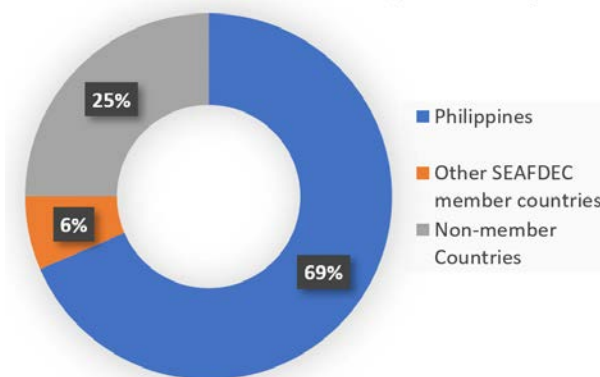
Using R & D to revive shrimp industry (12 December 2017, page 7)

The Philippine Star

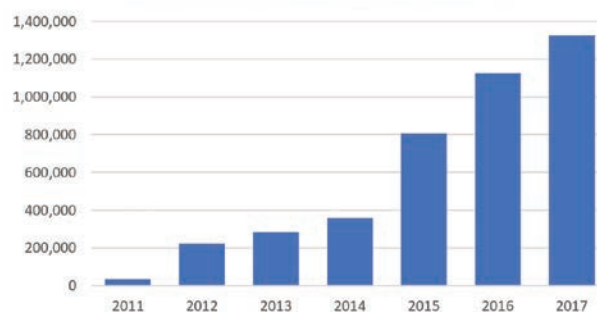
SEAFDEC to feature aquaculture technologies at Agrilink (22 July 2017, page B-8)

Gov't moves to boost blue crab production (5 March 2017, page B-5)

Website visitors by country



SAIR Downloads (2011-2017)



Panay News

Can bangus from Tigbauan feed the world? (4 November 2017, page 1, 2, 14)

Philippine Information Agency

Gov't to restock Laguna lake, other inland waters with native fish species (4 May 2017)

ABS-CBN News TV

Bandila: Summer adventure sa isang isla sa Guimaras (4 April 2017)

GMA Public Affairs TV

Born to Be Wild: Saving the 'Pawikans' (10 September 2017)



Some of SEAFDEC/AQD's appearances on television (top center) and print media

Exhibitions and Techno-forums

SEAFDEC/AQD participated in 8 exhibitions and organized one to promote its sustainable aquaculture technologies and to distribute aquaculture books, manuals and brochures that it produced. Notably, SEAFDEC/AQD sponsored the Agrilink 2017, the largest annual agribusiness exhibition in the Philippines visited by around 25,000 visitors, which was held in October. Highlighted during the exhibition were technologies on soft shell crab production, grow-out of single oysters in pouches, use of seaweed plantlets from tissue culture, and aquaculture of abalone.

Several techno-forums were also organized to bring stakeholders and SEAFDEC/AQD experts together for a series of technical seminars and consultations. These forums were held in conjunction with exhibitions during the 61st Aklan Day Agri-Aqua Fair held in April, Aqua-

culture Philippines 2017 in May, and Agrilink 2017. Apart from exhibitions, techno-forums were also held during the SEAFDEC/AQD anniversary activities in July and the Davao Agri-Trade Expo held in September. Each event involved between 80 and 150 stakeholders.

During the 11th Shrimp Congress held in Bacolod City in November, SEAFDEC/AQD also sponsored a SEAFDEC Night wherein Oplan Balik Sugpo, an initiative to revive the *Penaeus monodon* industry was launched in the presence of stakeholders from the shrimp industry.



SEAFDEC/AQD's island booth during the Agrilink 2017 exhibition at Pasay City

Exhibitions participated in or organized by SEAFDEC/AQD in 2017

| Exhibition or Event | Exhibit Highlight | Date | Venue |
|--|--|----------------|--------------------------------|
| Sustainable Seafood Week | Abalone | 21 February | City of Manila and Taguig City |
| Philippine Science High School Science Congress | Electron Microscopy | 22-28 February | Iloilo City |
| Exhibit for delegates to ASEAN Socio-Cultural Community Meeting | Commodities R&D programs | 9 March | Tigbauan, Iloilo |
| 61st Aklan Day Agri-Aqua Trade Fair | | 21-26 April | Kalibo, Aklan |
| Aquaculture Philippines 2017 | SEAFDEC/AQD milestones | 24-26 May | Pasay City |
| Fishlink 2017 | | 6-8 September | Iloilo City |
| Agrilink 2017 | Abalone Soft shell crab <i>Kappaphycus</i> Single oysters | 5-7 October | Pasay City |
| 5th Tilapia Congress | Tilapia | 11-13 October | San Fernando City |
| 11th Shrimp Congress | Shrimp/prawn commodities | 16-18 November | Bacolod City |

Techno Forums conducted by SEAFDEC/AQD in 2017

| Technology Forum | Estimated Attendees | Date | Venue |
|---|---------------------|--------------|------------------|
| Aquaculture Technology Forum 61 st Aklan Day celebration | 80 | 21 April | Kalibo, Aklan |
| Technical Seminar Series Aquaculture Philippines 2017 | 150 | 26 May | Pasay City |
| Farmers Forum 44 th SEAFDEC/AQD Anniversary | 110 | 6 July | Tigbauan, Iloilo |
| SEAFDEC Aquaculture Seminar Davao Agri Trade Expo | 100 | 23 September | Davao City |
| Technical Seminar Series Agrilink 2017 | 160 | 7 October | Pasay City |



Techno forum during the 61st Aklan Day Agri-Aqua Trade Fair



Technical seminars were packed during Agrilink 2017



Shrimp experts discuss strategies to revive the *P. monodon* industry during the launching of "Oplan Balik Sugpo"



Exhibit booth during the 11th Shrimp Congress

FishWorld

FishWorld, AQD's visitor center and museum of aquatic biodiversity received 6,640 guests in 2017. Twenty-two students participated in the Internship and On-the-Job Training Program of Fishworld, coming from 4 different high schools. The celebration of the annual Aquaculture

Week was participated by 6 high schools and 15 elementary schools from both public and private schools with about 116 students and 68 coaches participating in the various Science-Art Contests. FishWorld also works on the conservation of endangered megafauna. For

2017, 9 sea turtles were brought to Fishworld after being rescued from fish traps or found along the beach. Four of these turtles were released after tagging, 2 are under rehabilitation, while 3 died and were preserved.



School children participate in "Bring show and tell" contests



Student entries to the cloth art contest

Services & Extension

Several facilities operate in support of the research and development activities of SEAFDEC/AQD. These facilities are likewise availed by the private sector, the academe and government. Technical assistance is also provided to committed stakeholders who wish to venture into aquaculture or improve existing operations.

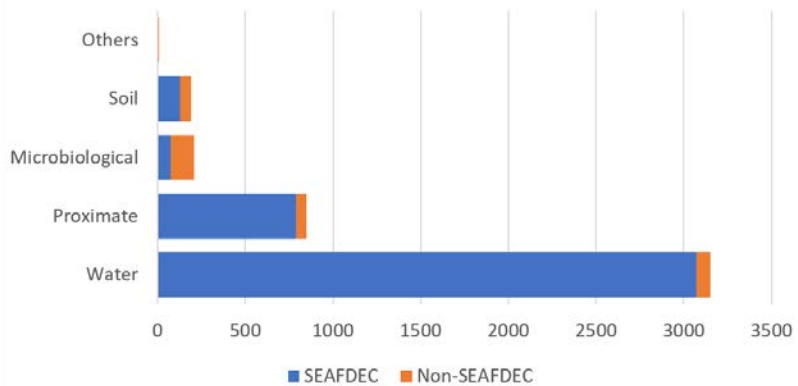


Electron Microscopy. SEAFDEC/AQD's Transmission Electron Microscope is used to image samples submitted by both in-house and external research projects.

Analytical Services

The Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT) conducts proximate, water, soil and microbiological analysis. LFAAT accepted 4,408 samples which were subjected for 13,473 determinations. Most of the samples were analyzed in support of SEAFDEC/AQD's various research programs while some also were submitted by stakeholders from the private sector and the academe. Bulk of the samples analyzed were water (3,151) with ammonia-N being the most-determined parameter. Other services that received samples were proximate analysis, (847), microbiological analysis (208), soil (192), electron microscopy (10), and fatty acid profile (4).

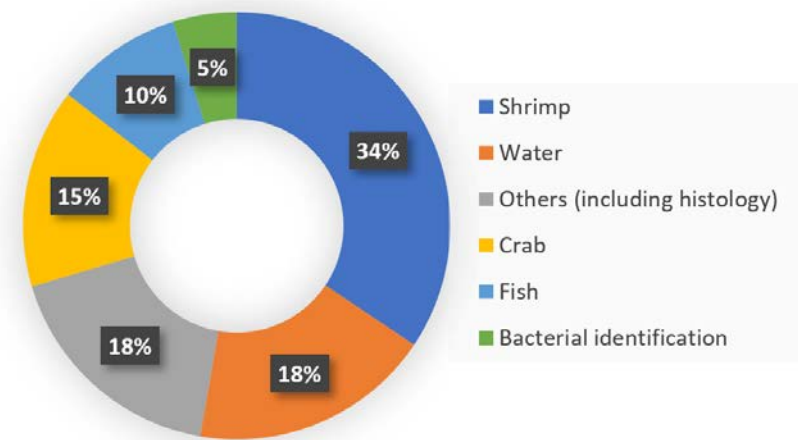
Samples accepted for analysis



Diagnostic Services

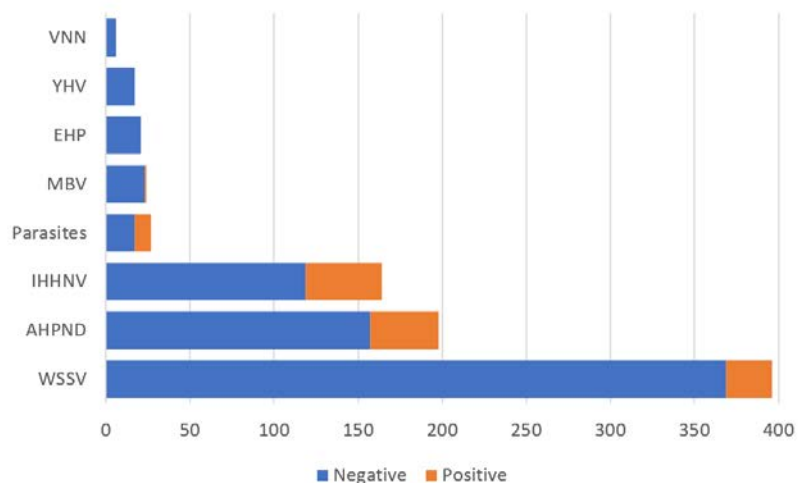
The Fish Health Section handles diagnostic cases for a range of viruses, bacteria and parasites. Diagnostic services catered to 311 cases in 2017, mostly on shrimp (34%). Diseases were detected mainly through polymerase chain reaction (PCR). White spot syndrome virus (WSSV) was the disease of most interest with 396 samples tested, although only 6.8% of these tested positive.

Diagnostic cases examined



Bacterial count was also done on 190 samples and bacterial identification done for 6 samples. Meanwhile, the Microtechnique Laboratory released 946 slides for the 930 samples received.

Diagnosis summary



Larval Food Laboratory

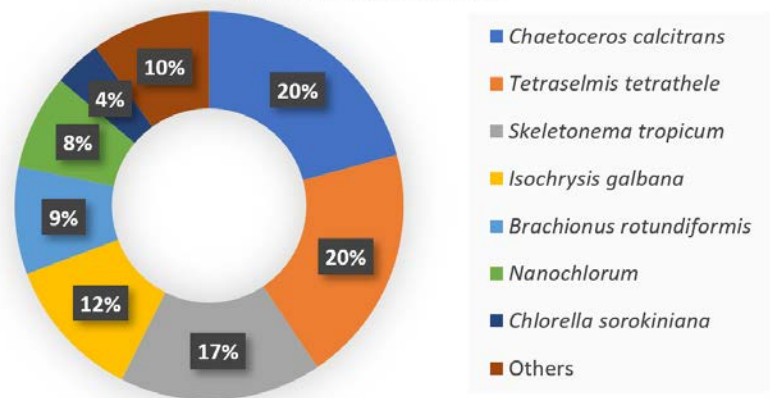
To support the research and production activities of AQD, the larval food laboratory served 20,714 liters (live) and 112.1 kg (paste) of microalgal and rotifer starters for oyster, sandfish, abalone, marine fish, annelids, *Artemia* biomass, *Proales*, shrimp and crab hatcheries. For *Artemia* biomass, 8.69 kg (wet weight) were prepared for the seahorse, crab and FishWorld requirements.

The laboratory also catered to 106 clients from the private sector (local, 57%; foreign, 4%), academe (26%), and government institutions (13%). The items sold included 1,129 liters of liquid microalgal/rotifer starters, 210g *Artemia* cysts, 5.1 kg of concentrated microalgal paste, 51 tube cultures, and pre-mixed fertilizers and culture media (184 liters TMRL, 226.6 liters F medium and 33.1 liters Conwy medium).



Carboys of green algae at the Larval Food Laboratory

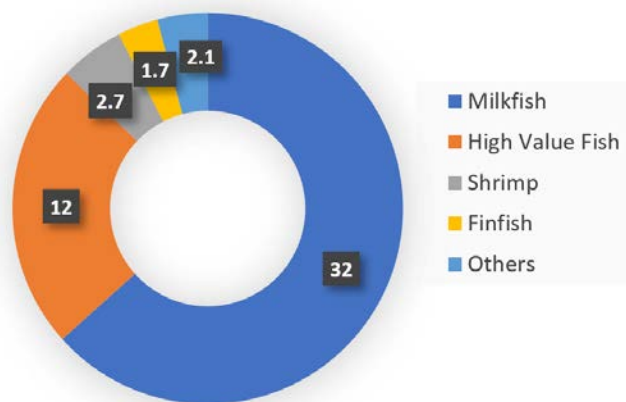
Types of liquid starters disposed to stakeholders



Feed Mill

Over 50 tons of aquafeeds for various commodities were produced by Feed Mill in 2017. About 76% of these were produced for studies funded by AQD and other agencies. The rest were for external clients which include private hatcheries, the Philippine Bureau of Fisheries and Aquatic Resources and the University of the Philippines Visayas.

Tons of aquafeed produced



Library Services

The present collection of SEAFDEC AQD Library stands at 45,395 titles and 75,302 copies of monographs, serials, vertical files and non-print materials. These were available for use and could be searched online through the AQD Library online public access catalog (OPAC). The OPAC was visited by a total of 21,013 global searchers. In addition, the library offers access to the following databases: ASFA, Springer, ProQuest Central, and TEEAL.

The Library served 1,153 readers, 90% of which were students, faculty, and researchers from different academic institutions in the country. 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 2,571 document requests were catered from about 1,200 individuals. Fifty-three percent



Reading area at the SEAFDEC/AQD Library

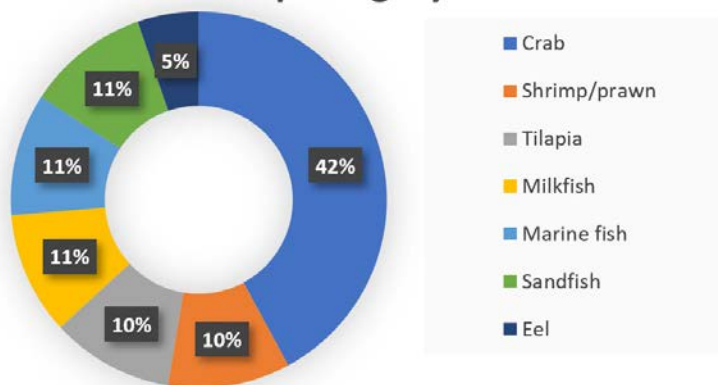
of the documents requested were placed in person, and remotely, thru email, phone, chat, and Facebook messenger, majority by SEAFDEC/AQD employees. While the remaining percentage of the documents requested were placed thru SAIR from 905 individuals

from more than 50 different countries. Majority of the requesters were from the Philippines, India, Malaysia, Indonesia, USA, Singapore, and Thailand, United Kingdom, Sri Lanka, Denmark, Germany, etc.

Technical Assistance

The ABOT Aquanegosyo program continued to offer technical assistance to private individuals who wish to enter the aquaculture business or refocus their existing farming activities. The year saw 22 clients on various stages of engagement. Most of the profiled clients (42%) were interested in the aquaculture of crab. While most client farm sites were spread across the Philippines, there were also clients from Singapore and Madagascar.

Commodities of interest among ABOT Aquanegosyo clients



Hatchery and Grow-out Production

Different aquatic commodities are produced as byproduct of different research and technology verification and demonstration activities at SEAFDEC/AQD. Milkfish continued to top hatchery production, producing over 100 million larvae. About 9 tons of market-size commodities were produced in 2017 with milkfish also topping the list. Also produced were 1,516 pieces of soft-shelled mangrove crabs.

Market-sized commodities produced by SEAFDEC/AQD as research and extension byproducts in 2017

| Commodity | Quantity (kg) |
|--------------------------|---------------|
| Milkfish | 7,173 |
| Snapper | 574 |
| Pompano | 349 |
| Seabass | 328 |
| Tilapia | 309 |
| <i>Penaeus indicus</i> | 249 |
| Siganid | 80 |
| Tiger shrimp | 11 |
| Grouper | 8 |
| Mangrove crab | 7 |
| Catfish | 2 |
| Soft-shelled crabs (pcs) | 1,516 |

SEAFDEC/AQD's hatchery production in 2017 by commodity

| Commodity | Quantity (pcs) | |
|----------------------------------|---------------------------|-----------------------------|
| | larvae | fry |
| Milkfish | 190,792,919 | 4,812,000 |
| Grouper | | |
| <i>Epinephelus coioides</i> | 6,745,045 | 23,358 |
| <i>Epinephelus fuscoguttatus</i> | 51,138,839 | 663 |
| Rabbitfish | 5,625,670 | 91,000 |
| Sea bass | 10,003,471 | 263,000 |
| Snapper | 29,638,477 | 128,850 |
| Pompano | 3,178,160 | 425,000 |
| Bighead carp | | 800,000* |
| Tilapia | | 108,407* |
| | | |
| Mangrove crab | 1,250,000 megalopae | 525,400 crab instars |
| Abalone | 16,238,665 veliger larvae | 68,503 juveniles |
| | | postlarvae/juveniles |
| Giant freshwater prawn | | 27,595* |

*based on sales data

New Collaborations

Academe

| Partner Institution | Nature of collaboration | Period |
|--|-----------------------------|-----------------------------|
| Aklan State University-New Washington (New Washington, Aklan, Philippines) | On-the-Job Training Program | |
| Central Philippine University (Jaro, Iloilo City, Philippines) | On-the-Job Training Program | |
| John B. Lacson Foundation Maritime University-Arevalo (Arevalo, Iloilo City) | Collaboration on Research | 1 Feb 2017 - 31 Jan 2022 |
| San Joaquin School of Fisheries (San Joaquin, Iloilo, Philippines) | Work Immersion Program | 15 Dec 2017 - April 2018 |
| West Visayas State University (La Paz, Iloilo City, Philippines) | On-the-Job Training Program | Nov 2017 - Feb 2019 |

Government and Non-Government Organizations

| Partner Institution | Nature of collaboration | Period |
|--|---|--------|
| Province of Southern Leyte (Southern Leyte, Philippines) | Internship Training of the Technical Staff for the Establishment of High-Value Marine Fish Hatchery | |

Private Sector

| Partner Institution | Nature of collaboration | Period |
|--|--|------------------------------|
| Aquascapes/ Ms. Lolita Ty (Quezon City, Philippines) | Commercialization of Soft-Shell Crab Production | 26 Aug 2017 - 27 Aug 2018 |
| INVE Asia Limited (Hongkong, China) | Determine the effect of application of probiotics and disinfectant to prevent and control infectious disease | |

Human Resources & Finance

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

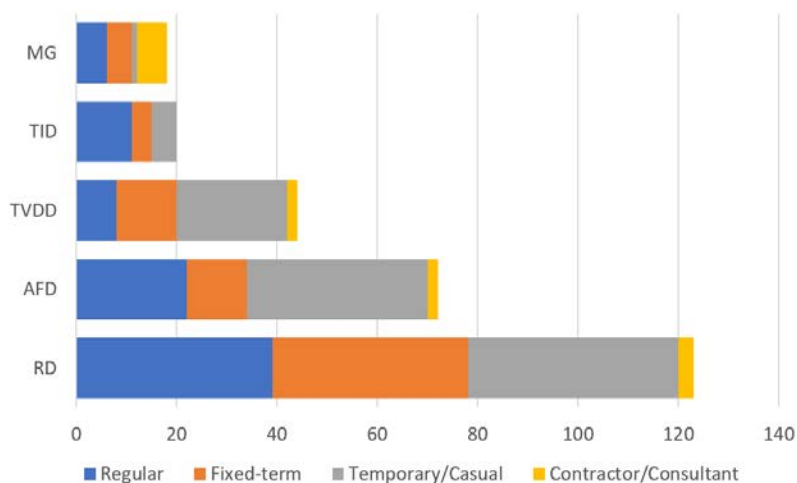
Anniversary group photo. Employees pose in front of SEAFDEC's 50th Anniversary icon at the Quadrangle during AQD's own 44th anniversary in July.



Personnel Distribution

As of end of 2017, SEAFDEC/AQD's personnel numbered 277 composed of 86 regular employees, 72 fixed-term staff, 106 on temporary or casual status, and 13 contractors/consultants. Close to half of the personnel (123) are assigned at the Research Division (RD).

Personnel Distribution



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, 7 personnel were sent to five international and one local event. Three were also allowed one week leave with pay to prepare for comprehensive and licensure examinations.



Scientist Dr. Maria Rowena Eguia served as one of two technical advisers for the Philippine delegation as she attended the 3rd UN Preparatory Committee Meeting on Biological Diversity Beyond Areas of National Jurisdiction with support from SEAFDEC/AQD (Photo by IISD/Francis Dejon (enb.iisd.org/oceans/bbnj/prepcom3/4apr.html))

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

| Event | Date | Location |
|--|--|---|
| Asian Pacific Aquaculture 2017 | 24-27 July 2017 | Kuala Lumpur, Malaysia |
| 3 rd UN Preparatory Committee Meeting on Biological Diversity Beyond Areas of National Jurisdiction | 03-07 April 2017 | New York, USA |
| World Aquaculture Conference | 26-30 June 2017 | Cape Town, South Africa |
| 7th International Oyster Symposium | 11-14 September 2017 | University of Wales, Bangor, United Kingdom |
| 8th Asian Pacific Phycological Forum 2017 | 08-13 October 2017 | Kuala Lumpur, Malaysia |
| Water Microbiological Test Training | 10-13 October 2017 23-26 October 2017 | Quezon City General Santos City |

Multi-purpose Hall inaugurated



The facade of the SEAFDEC/AQD Multi-Purpose Hall

The new Multi-Purpose Hall of SEAFDEC/AQD was inaugurated during the opening program of its 44th anniversary celebration on July 3, 2017. Former SEAFDEC/AQD chief Dr. Felix Ayson, under whose term the building broke ground, and current Acting Chief Dr. Chihaya Nakayasu led the cutting of the ribbon to finally open the Php 37-million facility.

Located near FishWorld, the new auditorium has state-of-the-art audio-visual facilities and can comfortably seat 500 in a banquet set-up or 700 in a theater arrangement. The auditorium may also be divided into 3 smaller function rooms to host simultaneous events.

The Multi-Purpose Hall is equipped with a modern digital audio mixer, three units of mobile public address system, one set of stage lighting, 25 units of conference-type microphone, six units of line array speakers, and six units of wireless microphones. In addition, it has a large-venue retractable projector with a display resolution of 1920 x 1200 pixels and a 4K enhancement technology display.



Ribbon-cutting ceremony in July 2017 led by then Acting Chief Dr. Chihaya Nakayasu and former Chief Dr. Felix Ayson and witnessed by the SEAFDEC/AQD community



Inside the Multi-purpose hall during one of the SEAFDEC/AQD anniversary events

Summary of Grants Received

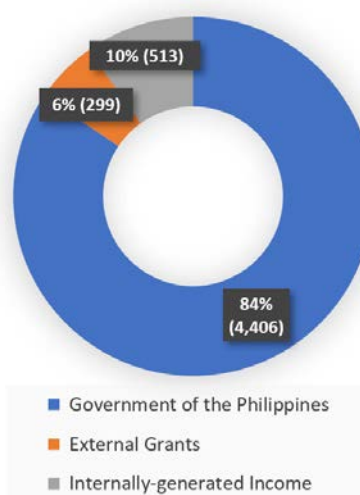
| Organization | Scope | Amount (US Dollar) |
|--|---|--------------------|
| Australian Center for International Agricultural Research (ACIAR) | Developing technologies for giant grouper aquaculture in Viet Nam, the Philippines and Australia | 39,493 |
| James Cook University (ACIAR) | Expansion and Diversification of Production and Management Systems for Sea Cucumbers in the Philippines, Viet Nam and Northern Australia | 21,576 |
| Research Institute for Humanity and Nature (RIHN) | Coastal Area Capability Enhancement in Southeast Asia | 5,847 |
| Department of Science and Technology (DOST) - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) | National Mud Crab Science and Technology Program | 99,883 |
| DOST-PCAARRD | National Oyster R & D Program | 26,879 |
| Department of Science and Technology-PCAARRD | Philippine Shrimp Pathogenomics Programs | 18,113 |
| Japan-Asean Integration Fund | EEL Project | 10,432 |
| Japan International Research Center for Agricultural Sciences (JIRCAS) | Development and extension of integrated multi-trophic aquaculture techniques for improvement of livelihood | 19,833 |
| JIRCAS | Advancing integrated multi-trophic aquaculture in milkfish mariculture in the Philippines: Ex-ante analysis using sustainable livelihood approach | 23,494 |
| JIRCAS | Value-Adding and improving economic efficiency & benefits in small holder IMTA milkfish mariculture in Guimaras, Philippines | 8,260 |
| Insol Foundation, Inc. | <i>Kappaphycus alvarezii</i> farming and its use as fertilizer for cacao tree | 4,639 |
| Tetra Tech ARD | Evaluation of potential sites, suitable culture species feasible culture systems and mitigation measures in the ecofish project focal areas | 20,837 |
| TOTAL | | 299,287 |

Statement of Financial Position

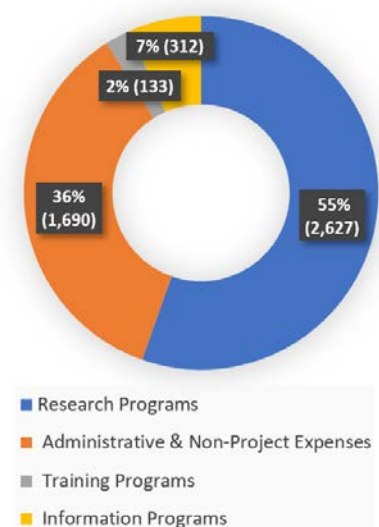
| (US Dollar '000) | | |
|---|---------------------|---------------------|
| | As of Dec. 31, 2017 | As of Dec. 31, 2016 |
| ASSETS | | |
| CURRENT ASSETS | | |
| Cash and cash equivalents | 3,010 | 2,480 |
| Accounts Receivables | 122 | 434 |
| Materials and Supplies | 49 | 54 |
| Other current assets | 2 | 1 |
| Total Current Assets | 3,183 | 2,969 |
| NON-CURRENT ASSETS | | |
| Cash investments | 268 | 270 |
| Other non-current assets | 266 | 114 |
| Total Non-current Assets | 534 | 384 |
| TOTAL ASSETS | 3,717 | 3,353 |
| LIABILITIES | | |
| CURRENT LIABILITIES | | |
| Accounts Payable | 530 | 786 |
| Funds Held-in-Trust | 259 | 107 |
| TOTAL LIABILITIES | 789 | 893 |
| NET ASSETS | | |
| Designated | 2,928 | 2,460 |
| Undesignated | - | - |
| Unrealized Gain on AFS | | |
| Financial Assets | | - |
| TOTAL NET ASSETS | 2,928 | 2,460 |
| TOTAL LIABILITIES AND NET ASSETS | 3,717 | 3,353 |

Note: The 2017 figures stated on this page are unaudited pending the completion of an external auditor's report.

Sources of Funds
('000 USD)



Allocation of Funds
('000 USD)



| STATEMENT OF REVENUES & EXPENDITURES (US Dollar '000) | | |
|---|--------------------------------|--------------------------------|
| | Period ending Dec. 31, 2017 | Period ending Dec. 31, 2016 |
| REVENUES | | |
| Contributions / Grants | 4,705 | 5,074 |
| Other Income | 512 | 476 |
| TOTAL REVENUE | 5,217 | 5,550 |
| EXPENDITURES | | |
| Research Programs | 2,627 | 2,860 |
| Training Programs | 113 | 97 |
| Information Programs | 312 | 216 |
| General Administrative and Non-Project Expenses | 1,690 | 1,519 |
| TOTAL EXPENDITURES | 4,742 | 4,692 |
| BALANCE | 475 | 858 |

2017 Heads of Offices

Executive/Management Committee

| | |
|--------------|---|
| Chief | Mr. Dan Balião (beginning 7 Sept) |
| Deputy Chief | Dr. Chihaya Nakayasu (Acting Chief until 6 Sept) |
| Head, RD | Dr. Evelyn Grace Ayson (until 7 Sept) Dr. Leobert de la Peña (beginning 8 Sept) |
| Head, TVDD | Dr. Fe Dolores Estepa (until 7 Sept) Mr. Dan Balião (beginning 8 Sept) |
| Head, TID | Dr. Ma. Junemie Hazel Ramos (until 7 Sept) Dr. Edgar Amar (beginning 8 Sept) |
| Head, AFD | Ms. Jasmine Gelvero (until 5 Feb) Ms. Jiji Rillo (6 Feb - 7 Sept) Ms. Amelita Subosa (beginning 8 Sept) |

Station Heads/OIC

| | |
|---------------------|---|
| OIC, BFS | Dr. Maria Lourdes Aralar |
| Head, DBS | Dr. Emilia Quintio (until 7 Sept) Mr. Victor Emmanuel Estilo (beginning 8 Sept) |
| OIC, IMS | Mr. Mateo Paquito Yap |
| Head, Manila Office | Dr. Maria Rowena Eguia (until 13 Sept) Ms. Anna Maria Josefa Ortiz (beginning 14 Sept) |

Program Leaders

| | |
|---|--|
| Quality seed for sustainable aquaculture | Dr. Maria Rowena Eguia |
| Healthy and wholesome aquaculture | Dr. Mae Catacutan, Dr. Rolando Pakingking Jr. (until 25 Sept), Dr. Eleonor Tendencia (beginning 26 Sept) |
| Maintaining environmental integrity through responsible aquaculture | Dr. Maria Lourdes Aralar |
| Meeting social and economic challenges in aquaculture | Dr. Nerissa Salayo |
| Regional programs | Dr. Chihaya Nakayasu |

Section Heads/OIC

Research Division

| | |
|--------------------------------|---|
| Breeding and seed production | Ms. Milagros dela Peña (until 14 Aug) Dr. Fe Dolores Estepa (beginning 15 Aug) |
| Fish health | Dr. Rolando Pakingking Jr. (until 12 Sept) Dr. Eleonor Tendencia (beginning 13 Sept) |
| Nutrition and feed development | Dr. Roger Edward Mamauag |
| Farming systems and ecology | Ms. Maria Rovilla Luhan (until 11 Sept) Dr. Jon Altamirano (beginning 12 Sept) |
| Socioeconomics | Dr. Nerissa Salayo |

Technology Verification and Demonstration Division

| | |
|-----------------------------|--|
| Technology verification | Ms. Sheryll Avanceña (until 18 Sept) Dr. Roger Edward Mamauag (beginning 19 Sept) |
| Demonstration and packaging | Dr. Fe Dolores Estepa (until 18 Sept) Ms. Sheryll Avanceña (beginning 19 Sept) |

Training and Information Division

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

Administration and Finance Division

| | |
|----------------------------|---|
| Engineering | Engr. Zaldy Suriaga |
| Human resources management | Ms. Nira Grace Llona (until 30 March) Ms. Kimberly Dianne Abrogueña (31 March - 7 Sept) Sunshine Mae Salonga (beginning 8 Sept) |
| Budget-cashiering | Ms. Jiji Rillo |
| Accounting | Ms. Jasmine Gelvero (until 10 Sept) Ms. Jo Anne Coronel (beginning 11 Sept) |

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

Heads of offices during the SEAFDEC/AQD Christmas program.





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.

