



SEAFDEC/AQD HIGHLIGHTS 2021



ANNUAL REPORT
Southeast Asian Fisheries Development Center
AQUACULTURE DEPARTMENT



WORLD'S FIRST: SEAFDEC/AQD spawns the shortfin scad, first step to farming 'poor man's fish'

A scientific breakthrough at SEAFDEC/AQD was made in 2021 with the successful captive spawning of the shortfin scad *Decapterus macrosoma* in Tigbauan, Iloilo, marking a critical milestone towards farming the fish, locally known as “galunggong”.

Considered as the “poor man’s fish” in the Philippines and referred to generally as round scad, it is considered a staple in the Philippines with an annual average of 190,000 metric tons harvested by commercial and municipal fisheries between 2016 and 2020 according to government statistics. However, the figure pales in comparison to the 290,000 average annual catch in 2001–2005 and 277,000 in 2006–2010.

The haul could not keep up with market demand leading to increasing prices, now reaching US\$5 to US\$6 a kilo (compared to US\$1–2 a kilo in 2001-2010), and controversial moves to import the fish amid closed fishing seasons.

Researcher Ma. Irene Cabanilla-Legaspi said they started collecting wild breeders off southern Iloilo and Antique in 2020 as part of a Government of Japan-funded project. After collecting breeders from the wild, Cabanilla-Legaspi’s team transported them to SEAFDEC/AQD’s headquarters in Tigbauan and stocked them in fish tanks to prepare them for spawning.

It was the breeders they caught in August and October 2021 that began laying eggs in December 2021. Incidentally, redbtail scad (*Decapterus kurroides*) breeders caught by the team along with the shortfin scad also spawned around the same time.

Meanwhile, the SEAFDEC/AQD team will continue to collect broodstock from the wild for more experimental runs that will also cover studying the fish’s larval development, reproductive development, feeding habits, and the formulation of hatchery, nursery, and grow-out procedures.

The research is under an umbrella program, funded by the Government of Japan Trust Fund (GOJ-TF), that aims to develop aquaculture technologies on new aquatic species that also includes “kawakawa” (mackerel tuna) and flathead lobster. The main goal of the research program is to close the life cycle of these species in captivity and to develop production techniques for hatchery, nursery, and grow-out.



Fertilized eggs of shortfin scad



Hatched larvae (day 0) of shortfin scad

MESSAGE OF THE CHIEF



We were off to a running start this 2021 as our over 50 approved research and development projects continued to strive towards their objectives in the midst of the new normal of the ongoing COVID-19 pandemic. Because of our hard-working scientists and researchers, we published a remarkable 41 scientific journal articles in 2021 alone.

We are also proud of our very own Centralized Analytical Laboratory for having earned an ISO/IEC 17025:2017 accreditation for biological and chemical testing. This ensures that our accredited analyses, as well as those we provide to the public, adhere to the highest standards.

We continued to ramp up production of seeds to serve the needs of fish farmers, even as we continued with the construction of new seed production facilities. Along with these, we acquired hundreds of new milkfish broodstock in

preparation for even more production in the coming years.

Our training program has fully adapted to the new normal with the production of training material that enabled the conduct of over 15 online training courses, not counting the face-to-face training courses we held where possible and health protocols allow.

Important partnerships were forged this year, one with a local fisherfolk cooperative to help them establish their own feed mill. This is a model that we hope could be eventually replicated throughout the region to help farmers cope with the high cost of feeds. We also inked an agreement with the Mindanao Development Authority to accelerate techno-transfer to fisherfolk in the Philippines' second-largest island. If done right, this could open up many investment and livelihood opportunities in aquaculture there.

We ended the year on a high note. It was in December when Department of Agriculture Secretary William Dar graced the inauguration of our long-awaited priority infrastructure projects. With the completion and full utilization of our new milkfish broodstock tanks and the multi-species marine and freshwater hatcheries, we have taken more strides towards helping our host country achieve fry sufficiency. Of course, we must mention that while these new facilities are the models, they are complement-

ed by the dozens of other government and private hatcheries lined up for construction or rehabilitation around the Philippines, many of which we are also involved in through partnerships with the Bureau of Fisheries and Aquatic Resources.

It was also in December when we achieved another major breakthrough with the spawning and hatching of the shortfin scad (*Decapterus macrosoma*) we collected from the wild. This is first documented spawning of shortfin scad in the world, and a milestone as we hope to eventually develop larval rearing, nursery, and grow-out technologies for this commercially-important species. We are excited to how the larvae and the technology would grow and develop in the next years, especially with the support being given by the Government of Japan Trust Fund.

We look upon our accomplishments as a benchmark for more challenges ahead of us. We are committed to do everything humanly possible, with the support of our partner agencies and donors, to address all these with dispatch and dedication for the sake of getting "more food on the table" now and in the years to come.

Dan D. Baliao
Chief, SEAFDEC/AQD

CONTENTS

Message of the Chief	1	REGIONAL PROGRAMS	
Research & Development Programs in 2021	3	Fish Health & Sustainable Aquaculture	35
Priority Programs	7	Training & Information	43
THEMATIC PROGRAMS		Production & Services	55
Quality Seed for Sustainable Aquaculture	15	Human Resources & Finance	61
Healthy & Wholesome Aquaculture	21	Collaboration in 2021	66
Maintaining Environmental Integrity	27	Heads of Offices	67
Meeting Social & Economic Challenges	31	Priority Infrastructure Projects	68
Adapting to Climate Change	33		

SEAFDEC/AQD HIGHLIGHTS 2021

ISSN 1655-5228

Published and printed by:
Southeast Asian Fisheries Development Center
Aquaculture Department
Tigbauan, Iloilo, Philippines



Copyright © 2023 Southeast Asian Fisheries Development Center, Aquaculture Department

Some rights reserved. This work is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-sa/3.0/igo/>.



This license requires that reusers of the material give credit to the licensor, the Aquaculture Department of the Southeast Asian Fisheries Development Center. Reusers may distribute, remix, adapt, and build upon the material in any medium or format, for noncommercial purposes only and not in any way that suggests the licensor endorses the reuser. If others modify or adapt the material, they must license the modified material under identical terms.

ACKNOWLEDGMENTS

Contributors: Program leaders, study leaders, section heads, office and laboratory staff

Technical review: LD de la Peña, EC Amar, JP Altamirano, REP Mamauag, ND Salayo, EA Tendencia, program leaders, study leaders

Editing and layout: RD Dianala

2021 RESEARCH & DEVELOPMENT PROGRAMS



PRIORITY PROGRAMS OF SEAFDEC/AQD

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

THEMATIC PROGRAMS

Study Title	Main Proponent	Collaborating Partners
Quality Seed for Sustainable Aquaculture		
1	Precocious puberty in milkfish through endocrine manipulation	PA Palma
2	Development of a protocol for large-scale culture of harpacticoid copepods for marine fish larviculture	MAE Mandario
3	Use of microalgal paste-fed <i>Proales similis</i> in marine fish larviculture	AV Franco
4	Use of biofloc system to improve water quality, growth performance and disease resistance of <i>Penaeus monodon</i> and <i>Penaeus indicus</i> juveniles reared in tanks	EGE Superio
5	Nursery culture of mangrove crab <i>Scylla serrata</i> megalopae in pond-based net cage	P Caballero

Study Title		Main Proponent	Collaborating Partners
6	Nursery and grow-out culture of snubnose pompano <i>Trachinotus blochii</i> in pond-based net cages	P Caballero	
7	Use of andrectomized males (neo females) giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) for the production of all-male progenies	MB dela Cruz	
8	Verification of adequate feeding rations and use of algal paste for single seed spat production of slipper-shaped oyster <i>Crassostrea iredalei</i>	MS Espino	
9	Optimizing the survival of micopropagated seaweed <i>Kappaphycus alvarezii</i> through acclimation in tank-based nursery systems	HS Pitogo	
10	Economic viability of tank-based polychaete culture technology	MAE Mandario	
11	Development of a modified continuous culture system for the mass production of <i>Nanochlorum</i> sp. and <i>Brachionus rotundiformis</i>	MR de la Pena	
12	Optimizing hatchery production of early juveniles sandfish <i>Holothuria scabra</i>	JP Altamirano	
13	Seed production of donkey's ear abalone <i>Haliotis asinina</i>	SMB Ursua	
14	Seed production of freshwater prawn, <i>Macrobrachium rosenbergii</i>	EE Superio	
15	Mass production of mangrove crab (<i>Scylla serrata</i>) seedstock	EE Superio	
16	Sea-based nursery cage production of farmed eucheumatoids	JP Faisan Jr.	
17	Production of farmed eucheumatoids by micropropagation in the land-based nursery	HS Pitogo	
Healthy and Wholesome Aquaculture			
18	Cost effective ingredients blend of soybean meal, corn protein concentrate, poultry by-product meal, hemoglobin meal and protein enhanced copra meal in the diets of pompano, <i>Trachinotus blochii</i>	RE Mamauag	
19	Development and evaluation of fungi-fermented feed ingredients as alternative protein sources in milkfish diet	JB Biñas	
20	Production techniques for culture of silver therapon (<i>Leiopotherapon plumbeus</i>) in tanks and cages	FA Aya	
21	Grow-out culture of abalone comparing the use of <i>Gracilariopsis heteroclada</i> and SEAFDEC formulated diet as feeds	MJHL Ramos	
22	Test of refined formulated feed for the grow-out culture of mangrove crab, <i>Scylla serrata</i> (Forsskal) in land based tanks	MB Teruel	
23	Nutritional interventions to improve reproductive performance of Indian white prawn, <i>Penaeus indicus</i> (H. Milde Edwards, 1837) (Dissertation)	SS Avancena	DOST / UPV

Study Title		Main Proponent	Collaborating Partners
24	Detection, control and treatment of persistent and emerging pathogens affecting pond cultured Asian catfish (<i>Clarias macrocephalus</i>)	RV Pakingking Jr.	
25	Detection, quantification, and viability of Tilapia Lake Virus (TiLV) in pond soil and water as influenced by water quality parameters and culture management	DJC Logronio	
26	Safeguarding the future of the seaweed industry of the Philippines: Disease and pest detection (WP1)	J Faisan/ Juliet Brodie (I) J Faisan/ MRJ Luhan (II) AQ Hurtado/ MRJ Luhan/ J Faisan (III)	UKRI (previously RCUK) Global Challenge Research Fund (GCRF) GlobalSeaweedSTAR
27	Efficiency and profitability of Nile tilapia (<i>Oreochromis niloticus</i>) - giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) polyculture in pond-based biofloc system with refinements on feeding rates	MB dela Cruz	
28	Pilot field trials to evaluate emamectin benzoate, hydrogen peroxide and freshwater bath to reduce a natural infestation of sea lice on snub-nose pompano <i>Trachinotus blochii</i>	GE Pagador	
29	Efficiency of polychaete phospholipid in promoting <i>Penaeus monodon</i>	SS Avancena	
30	Verification of probiotic supplementation in enhancing growth, survival and immune response of juvenile abalone	MS Espino	
31	Field verification of the vaccination regimen in cage-cultured marine fish species (pompano, snapper, grouper) broodfish in Igang Marine Station as a practical strategy to prevent the vertical transmission of nervous necrosis virus during seed production	RV Pakingking Jr.	
32	Culture of pompano <i>Trachinotus blochii</i> in floating net cages	RE Mamauag	
33	Demonstration of grow out techniques of commercially-viable shrimp species (<i>P. monodon</i>)	RE Mamauag	
Maintaining Environmental Integrity Through Responsible Aquaculture			
34	Strategic feeding of milkfish (<i>Chanos chanos</i>) for efficient marine cage culture production	PA Palma	
35	Increasing technical skills supporting community-based sea cucumber production in Vietnam and the Philippines	JP Altamirano	ACIAR
36	Development of optimal fish-prawn co-culture schemes in tanks and lake-based cages for increased farm production	MRR Eguia	
Meeting Social and Economic Challenges in Aquaculture			
37	Assessment and development of community-based sea cucumber (<i>Holothuria scabra</i>) farming livelihood for fishing communities	RJG Castel	ACIAR

Study Title		Main Proponent	Collaborating Partners
Attaining Sustainable Aquaculture through Cost-Effective Culture Systems and Prompt and Effective Aquatic Animal Health Management			
38	Surveillance and epidemiology of EHP (<i>Enterocytozoon hepatopenaei</i>) in Philippines	GE Pagador	GOJ-TF
39	Application of integrated approaches in the management of viral and other emerging diseases in brackishwater ponds	EC Amar	GOJ-TF
40	Generation and application of optimized procedures in disease control and management against emerging shrimp and fish diseases in Southeast Asia	LD de la Peña	GOJ-TF
41	Ecosystem approach to a responsible/sustainable farming for small scale farmers that are into extensive mono or polyculture of shrimp	EA Tendencia	GOJ-TF
42	<i>In vitro</i> and on farm investigation of organisms, chemicals, and methods to prevent or mitigate the effect of important shrimp diseases	EA Tendencia	GOJ-TF
43	Development of aquaculture technique on new aquatic species (flathead lobster, <i>Thenus orientalis</i>) for promotion and creation of local aquaculture industry	SMB Ursua	GOJ-TF
44	Development of aquaculture technique on new aquatic species (kawakawa <i>Euthynnus affinis</i> and <i>Decapterus macrosoma</i>) for promotion and creation of local aquaculture industry	MIC Legazpi	GOJ-TF
45	Promoting alternative feeds for sustainable production of freshwater aquaculture species	FA Aya	GOJ-TF
46	Developing community-based sustainable aquaculture livelihood strategies in Laguna lake and tributaries	ND Salayo	GOJ-TF

SPECIAL PROJECTS

47	Joint Mission for Accelerated Nationwide Technology Transfer Program for Aquaculture (JMANTTP-II) (Hatchery and grow-out technology for selected finfish, crustacean, mollusc and seaweeds)	DD Baliao	BFAR
48	Demonstration and verification of sustainable and efficient aquaculture techniques by combination of multiple organisms	R Nambu (ND Salayo) (M Kodama)	JIRCAS
49	Pompano (<i>Trachinotus blochii</i>) production in brackishwater ponds	DD Baliao	
50	Mudcrab (<i>Scylla serrata</i>) farming in brackishwater ponds	DD Baliao	

Abbreviations used

ACIAR	Australian Centre for International Agricultural Research	JIRCAS	Japan International Research Center for Agricultural Sciences
BFAR	Bureau of Fisheries and Aquatic Resources	NFRDI	National Fisheries Research and Development Institute
DOST	Department of Science and Technology	UKRI	UK Research and Innovation
GCRF	Global Challenge Research Fund	UPV	University of the Philippines Visayas
GOJ-TF	Government of Japan - Trust Fund		

SEAFDEC/AQD PRIORITY PROGRAMS



Since 1973, SEAFDEC/AQD has developed aquaculture technologies and trained thousands of stakeholders. However, the adoption of technology remains to be lagging and there are persistent problems such as the supply of seed, the cost of feeds, diseases, and the limited technical personnel. To accelerate the application of science-based technologies and approaches, SEAFDEC/AQD is working in close partnership with national agencies in the Philippines, the department's host country. Together, they aim to address longstanding problems in the aquaculture sector.

Fry Sufficiency Program

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

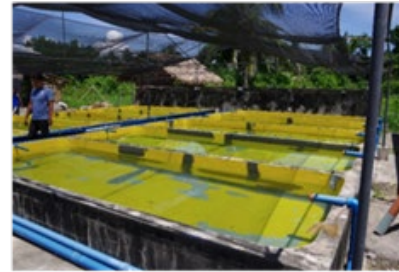
In response to the insufficiency of milkfish (*Chanos chanos*) seeds, the Department of Agriculture's Bureau of Fisheries and Aquatic Resources (DA-BFAR) partnered with SEAFDEC/AQD through a Memorandum of Agreement (MOA) to assess the feasibility of constructing more hatcheries in the country and to revive those that have become unproductive. Out of the 16 proposed sites for new government hatcheries, nine sites passed the evaluation and detailed engineering layouts were already provided to DA-BFAR by the end of the MOA in May 2021. Progress on seven other potential hatchery sites were hampered by problems on land ownership and suitability.

Meanwhile, DA-BFAR Region 6 entered into a new contract with SEAFDEC/AQD for the feasibility study of six new house bills mandating new hatcheries. Out of six proposed locations, three have completed feasibility studies. SEAFDEC/AQD is also working alongside DA-BFAR 6 and the private sector to revive unproductive hatcheries. So far, a private hatchery in Batan, Aklan and a state college hatchery in Concepcion, Iloilo were reconstructed with SEAFDEC/AQD providing training, milkfish larvae, and starters for algal culture. The Batan hatchery has already successfully started producing milkfish fry.

Batan, Aklan



Before



After

Concepcion, Iloilo



Before



After

The hatchery at the Northern Iloilo Polytechnic State College (NIPSC) in Concepcion, Iloilo that is being subject to rehabilitation in coordination with BFAR.



In March and April 2021, hundreds of milkfish breeders were stocked in SEAFDEC/AQD's newly-constructed broodstock facilities in Tigbauan, Iloilo, Philippines.

Revived hatchery signals major step to Philippine milkfish fry sufficiency

The embattled milkfish industry in the Philippines got a shot in the arm as the first rehabilitated hatchery in Western Visayas, which is expected to produce 5 to 10 million bangus fry every year, started its operations to address the persistent shortage of milkfish seeds in the country.

Located in the province of Aklan, the 1,787 square meter Batan Bangus Satellite Hatchery was launched in February this year under the National Fry Sufficiency Program of the Department of Agriculture's Bureau of Fisheries and Aquatic Resources (DA-BFAR).

The hatchery used to produce shrimp fry in 1983 but outbreaks of diseases in shrimp during the 90s led the hatchery to cease its operations in 1995. Now, it is one of the central hubs that produce quality, locally-produced milkfish fry in Western Visayas.

To jumpstart the hatchery's operations, 1.1 million pieces of milkfish larvae and 30 liters of rotifers were donated and turned over by SEAFDEC/AQD in February.

"The revival of the satellite hatchery in Batan is simply the beginning of many yet to come," SEAFDEC/AQD Chief Dan Baliao stated in an interview.

Aside from the hatchery in the Municipality of Batan, another satellite hatchery located in the campus of the Northern Iloilo Polytechnic State College in Concepcion town is gearing up for its operations.

In southern Iloilo, SEAFDEC/AQD identified 12 hatcheries that were abandoned or are non-opera-



Technical staff of the Bangus Satellite Hatchery in Barangay Songcolan, Batan, Aklan, begin to count their harvested milkfish fry. *Photo courtesy of WD De Los Santos*

tional because of sickness or death of its owner, bankruptcy and lack of finances to continue operations.

Baliao reiterates that by rehabilitating these identified sites, the production of milkfish fry in the country would be maximized to meet the yearly Philippine demand of about 2.5 billion. To meet this massive requirement for fry, farmers have resorted to the importation of fry from neighboring countries.

About half of the 400,000 metric tons of milkfish consumed by Filipinos were sourced as fry from hatcheries in Indonesia and Taiwan before being imported for grow-out in the Philippines, according to industry sources.

"This collaborative undertaking with BFAR, SEAFDEC, and private partners is a step forward to

answer the shortage of bangus fry and to curb our dependence on its importation," stated Wilfredo D. De Los Santos, Chief of the Fisheries Production Support and Services Division, BFAR Region 6.

The hatchery technicians and staff of the Bangus Satellite Hatchery in Batan town harvested their first batch of milkfish fry last March 2021, which was then stocked in a nearby nursery pond.

As the focal person of the Bangus Sufficiency Program in the region, De Los Santos also further emphasized that the involvement of the agencies and key industry players is a "necessary investment" to achieve fry sufficiency in the country.

SEAFDEC/AQD inaugurates new aquaculture facilities; strengthens government partnership

Newly-established aquaculture facilities at SEAFDEC/AQD were officially inaugurated in a ceremony held last 9 Dec. 2021 at its Tigbauan Main Station in Iloilo, Philippines. Top executives of the Philippine government, headed by Department of Agriculture (DA) Secretary Dr. William Dar, toured the facilities with Chief Dan Baliao and the members of the SEAFDEC/AQD Executive Committee.

Multi-species hatcheries and broodstock tanks were established to intensify the research center's demonstration and techno-transfer program as well as help address the shortage of aquaculture seeds in the Philippines.

"Science and technology is the engine of growth for aquaculture and fisheries," said Sec. Dar in his speech. He expressed his gratitude to SEAFDEC/AQD for its work, particularly for the ready-for-adoption technologies it developed for economically important aquaculture species.

The Secretary then challenged the research center to scale up the verification and demonstration of the technologies in partnership with Philippine government agencies including DA's Bureau of Fisheries and Aquatic Resources,

National Fisheries Research and Development Institute, and local government units.

"The [Philippine] government is rooting for SEAFDEC/AQD and its efforts towards sustainable aquaculture," he added.



Department of Agriculture Secretary Dr. William Dar (center left in black) and SEAFDEC/AQD Chief Dan Baliao (center right in white) lead the ceremonial ribbon cutting

Development of Cost-Efficient Feeds

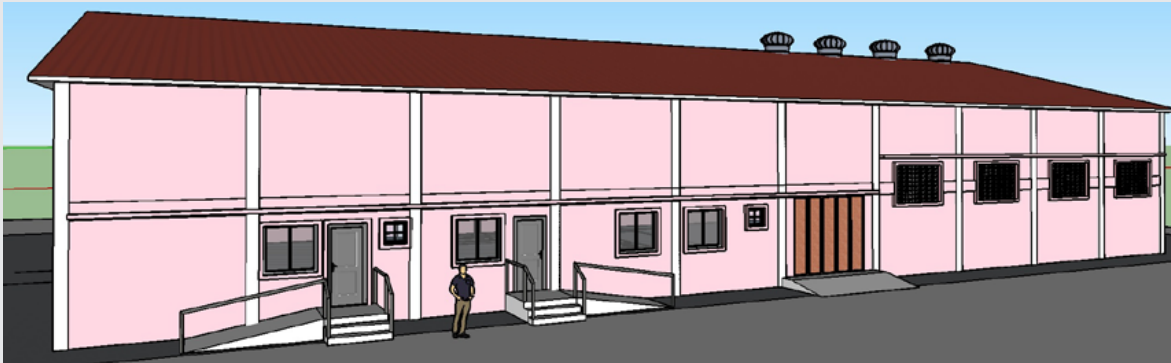
Since 2019, SEAFDEC/AQD has been testing cost-efficient diet formulations for milkfish and tilapia, using alternative ingredients to replace fish meal which is an expensive and unsustainable resource. The SEAFDEC/AQD-formulation uses poultry by-products, distillers dried grains solubles, and protein enhanced copra meal which were shown to have potential based on SEAFDEC/AQD's published research findings. Field testing is being done

in different areas in the Philippines in collaboration with the DA-BFAR and the National Fisheries Research and Development Institute (NFRDI).

The field testing of cost-efficient feeds for milkfish and tilapia continued in 2021 with field tests completed at the Dumangas Brackishwater Station in Iloilo for tilapia in ponds, at Sto. Tomas, La Union for milkfish in sea cages, and Agoncillo, Batangas for both

milkfish and tilapia in lake cages. The culture runs returned similar results showing that the SEAFDEC/AQD-formulated diets caused better growth in the fish, better survival, higher total harvest weight, and better feed conversion ratio. In 2022, a training course for potential field-testing cooperators will be done prior to the roll out of the cost-efficient feeds to their farms.

Feed Mill by Aquafarmers, for Aquafarmers



A fish farmers' cooperative is set to establish their own feed mill in Capiz, Philippines after an agreement with SEAFDEC/AQD was formalized for the Department to assist in planning and setting up the facility.

The feed mill will produce low-cost feeds using SEAFDEC/AQD's

formulations to help local fish farmers reduce their cost of production. Feed cost continues to be the most significant expense in aquaculture, comprising over half of the total production cost.

SEAFDEC/AQD Chief Mr. Dan Bali-ao signed a memorandum of agreement (MOA) with the Panay Aqua

Farmers Consumers Cooperative (PAFCC) on 24 Sept. 2021 at the Tigbauan Main Station. The Chief said the Department's researchers, engineers, and economists have been working on the feasibility study of the feed mill for almost a year, but it is set to be completed very soon.

Oplan Balik Sugpo

The tiger shrimp (*Penaeus monodon*) industry continues to struggle to thrive given the persistent occurrence of various shrimp diseases. To facilitate the revival of the industry, AQD launched the *Oplan Balik Sugpo* (Operation Black Tiger Shrimp Revival) program in 2017 with the goal of producing high-quality tiger shrimp postlarvae and promoting the environment-friendly grow-out culture of tiger shrimp.

In 2021, the Shrimp Hatchery Complex of SEAFDEC/AQD produced 2.08 million postlarvae for the first six months. Some of these were stocked in the brackishwater ponds of the Dumangas Brackishwater Station in June for research and verification purposes, while others were sold to buyers. In October, after 123–126 days of culture



Harvesting tiger shrimp postlarvae at the SEAFDEC/AQD Shrimp Hatchery Complex

at the Dumangas Brackishwater Station, a total of 9.6 tons of tiger shrimp were harvested in two batches from three ponds totaling

21,303 m³. The recorded average body weight was 29–30 g with 80–90% survival.

JMANTTP II: Joint Mission for Accelerated Nationwide Technology Transfer Program

Despite continuing COVID-19 restrictions, an on-site training course for fish farmers was conducted in Roxas City, Capiz. Thirty-four participants, composed of pond operators and growers, and individuals from the business sector, attended the training in February. The training module covered topics on mangrove crab, fish health, shrimp culture, recirculating aquaculture system, and milkfish deboning. Proper health protocols were strictly followed during the training. The training was done in collaboration with DA-BFAR 6, the Office of the Provincial Agriculturist Capiz, and the private sector (cooperatives and business sector).

Another training was done online for 95 participants from Kabasalan, Zamboanga Sibugay which were composed of fisherfolks, fish farmers, and members of the local government. The training focused on the importance of conducting a feasibility study and the aquaculture of oyster. Other topics on mangrove crab and grouper were also discussed. The training was in collaboration with the Mindanao Development Authority, Municipality of Kabasalan, and Kapunongan sa Gagmay'ng Mangingisda sa Concepcion of Kabasalan, Zamboanga Sibugay.

An online training course on mangrove crab culture was also conducted for the fisherfolks of Bangsamoro Autonomous Region in Muslim Mindanao. Thirty (30) fisherfolk participants from Maguindanao were the beneficiaries of the training course. This was in collaboration with the Ministry of Agriculture, Fisheries, and Agrarian Reform, specifically its Fisheries, Coastal Resources, and Livelihood Project.



Onsite Training Course on Aquaculture organized by SEAFDEC/AQD and the Bureau of Fisheries and Aquatic Resources (Region 6) in Roxas City on 23 to 24 Feb. 2021



On 21 to 22 October 2022, virtual training sessions on oyster, mangrove crab, and grouper, were streamed from SEAFDEC/AQD in Iloilo to fisherfolk in Kabasalan, Zamboanga Sibugay along with other attendees from different parts of the Philippines

Pact inked to jumpstart aquaculture development in Mindanao

More oysters and crabs may soon be spawning and growing in southern Philippines, once a recently-inked partnership between SEAFDEC/AQD and the Mindanao Development Authority (MinDA) gains traction.

Aiming to establish hatcheries to produce seeds and accelerate aquaculture development in Mindanao, the second largest island in the Philippines, SEAFDEC/AQD Chief Mr. Dan Baliao signed a three-year agreement with MinDA on 6 Sept. 2021 at Tigbauan, Iloilo.

The Memorandum of Agreement formalizes collaboration through techno-transfer programs, including verification and training in broodstock, hatchery, nursery, and grow-out operations of commercially viable finfishes, crustaceans, mollusks, and seaweeds.



Despite COVID-19 restrictions, Mr. Baliao said the research center will immediately meet its commodity leaders and find means to conduct trainings in Mindanao. Dr. Leobert de la Peña, head of the

AQD Research Division expressed support for the project and said that SEAFDEC/AQD is willing to share its expertise and technical capabilities to make the collaboration successful.

Manpower Development

In 2018, 16 graduates from different fisheries schools were given intensive training on shrimp, marine fish, and tilapia aquaculture. The manpower development training program intends to contribute to a pool of highly-skilled aquaculture personnel that operate aquaculture facilities in the country.

The pandemic hampered the conduct of subsequent trainings, but on July to October 2021, another batch of trainees were accommodated at SEAFDEC/AQD after hurdling a selection process and stringent COVID-19 restrictions.

Four fisheries graduates completed the second session of the three-month intensive training course at SEAFDEC/AQD.



Participants from Mindanao and Bicol region gain practical experience in pond preparation at Dumangas, Iloilo as part of the Manpower Development Program

The training course, titled “Manpower Development on Aquaculture Technologies,” accommodated three trainees from Mindanao and one from Luzon who were given hands-on exposure and training on shrimp, marine fish, mangrove crab, giant freshwater prawn, oyster, seaweed culture, as well as on the operations of brackishwater ponds and cages. They were also assigned to the Multi-Species Marine Fish hatchery, Oyster Hatchery, and Mangrove Crab Hatchery.

The last phase of their training included individual oral reporting and oral examination on hatchery and grow-out procedures – before a panel of evaluators. Topics covered include hatchery techniques for tiger shrimp, mangrove crab, marine fish, and giant freshwater prawn. Cage and pond grow-out culture of fish, as well as seaweed micropropagation, were also covered.



Trainees prepare natural food during their stint at the Mangrove Crab Hatchery



QUALITY SEED FOR SUSTAINABLE AQUACULTURE

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

Broodstock development

Milkfish

It takes 3.5 to 5.5 years for milkfish (*Chanos chanos*) to mature. A study was done to test if advancing the onset of puberty in milkfish was possible through endocrine manipulation. Two neuroendocrine hormones as well as a gonadal steroid are being considered.

So far, the gonadotropin-releasing hormone (GnRH) has been tested using different dosages and size groups of milkfish. At least 10% of milkfish fingerlings (70–100 g) injected with 100ug/kg of GnRH every two weeks for four months were found to have primary growth stage oocytes on the sixth month of rearing. Larger-sized milkfish juveniles (0.7–1 kg) treated with GnRH (5 ug/kg and 30 ug/kg) every two weeks for 4 months showed that 40% had primary growth stage oocytes.

These results indicate the onset of gonad differentiation and their sensitivity to hormonal manipulation. The gonad samples taken on the sixth month have comparable gonado-somatic index value regardless of treatment.



Ablated giant freshwater prawn postlarva, emphasizing surgical areas

Giant Freshwater Prawn

Male giant freshwater prawn (*Macrobrachium rosenbergii*) grow larger and reach marketable size faster than females. Production of all-male (monosex) prawn is thus being considered to improve yields in farms. Towards this, prior research has been done to sex-reverse male prawns into functional females (neo-females) which in turn give birth to all-male prawn. One of the methods to produce neo-females is the ablation (removal) of the androgenic gland in male

prawn. SEAFDEC/AQD has been working to verify the efficacy and cost-effectiveness of the procedure.

Partial results show that prawn ablated at PL45 produced a significantly higher percentage (23.5%) of potential neo-females 90 days after ablation, compared to those ablated at PL63-67 and PL95. Postlarvae that show signs of feminization will be monitored for gonadal development. Other activities to verify the efficacy and cost-effectiveness of the technique will be done in 2022.

Hatchery & nursery protocols

Shrimps

The use of biofloc technology in shrimp culture presents several advantages such as better biosecurity due to its zero-water exchange approach, improved feed efficiency, and enhanced growth and health of the shrimp. SEAFDEC/AQD aims to evaluate the efficiency of microbial biofloc produced using two different carbon sources to improve shrimp production and determine its effect on the disease resistance of shrimp.

In 2021, microbial floc produced using milkfish was found to be composed mostly of chlorophytes, protozoans, and nematodes. In rearing white shrimp *Penaeus indicus* and *Penaeus monodon*, growth parameters were mostly the same, except for survival which was significantly higher in biofloc tanks than non-biofloc tanks, regardless of the carbon source (wheat flour and molasses) used. As for the water parameters, total ammonia ni-

trogen was significantly lower in tanks that used biofloc. In a challenge experiment, both *P. indicus* and *P. monodon* were infected with *Vibrio parahaemolyticus*, the causative agent of the acute hepatopancreatic necrosis disease (AHPND) in shrimp. For both species, shrimp grown and infected within a biofloc system fared better than those grown and infected in non-biofloc water.

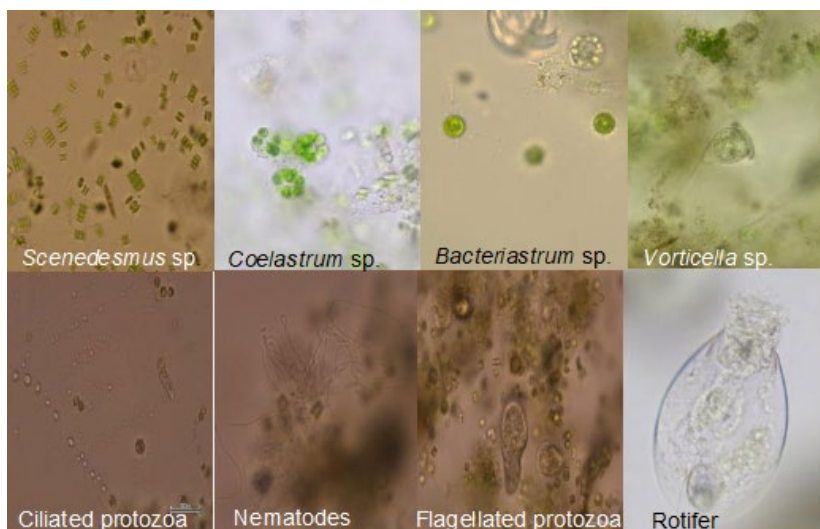
Pompano

The optimal conditions for nursery rearing of snubnose pompano (*Trachinotus blochii*) in pond-based net cages is being defined to improve yields. The best diet and the optimal stocking density for the growth and survival of pompano are being investigated.

Hatchery-reared pompano were stocked in nursery cages set in ponds at a density of 150/m³. After 135 days of culture (DOC), the treatment fed the pompano diet with taurine gave the highest specific growth rate (4.8%/day). Feed conversion ratio was significantly

lower in the treatment fed the commercial diet (1.9).

In the grow-out experiment, pompano from the nursery experiment (40–50 g) were stocked in cages in ponds at different densities (3/m³, 5/m³, 10/m³). The experiment was terminated at 79 DOC because of high mortalities. Growth, survival rate, and FCR did not differ significantly, but biomass was significantly higher at the 10/m³ stocking density. Another run will be done in 2022 using lower stocking densities between 0.3/m³ and 1/m³.



The dominant plankton species in tilapia and milkfish biofloc tanks were chlorophytes, ciliated and flagellated protozoa, nematodes, and rotifers



Hatchery-bred pompano juveniles at 1-inch body size (left), and 40–50 g weight after 135 days of culture (right)

Mangrove crab

Mangrove crab (*Scylla serrata*) is the most preferred species for farming in the Philippines due to its fast growth, large size, less aggressive behavior, and tolerance to a wide range of salinities. For grow-out, farmers prefer to stock crabs at the instar stage. However, to shorten the hatchery production phase, an approach to nurse crabs in pond-net cages beginning at the earlier megalopae stage is being verified.

Preliminary results show survival of up to 87% after four weeks for crab instars grown in pond net cages at a stocking density of 50/m³. This survival is similar to the 83% survival at the 100/m³ stocking density and higher than the survival rate at 200/m³ and 300/m³ (79% and 59% respectively). Data from a three-week rearing period gave a similar trend. More runs will be done in 2022, with closer monitoring of diseases caused by bacteria and viruses.

Oyster

A study was done to determine the optimal ration of algae to feed the larvae of slipper oyster (*Magallana bilineata*) and maximize growth and survival. Feeding rations tested for the different larval stages were

set at low, mid and high (starting at 15,000 cells/ml, 20,000 cells/ml and 25,000 cells/ml) with the rations increased as the oyster larvae grew. So far, results show that the number and survival rate of the larvae are higher in the treatments fed with mid and high feeding rations but these decreased through time. The study will continue through 2022.

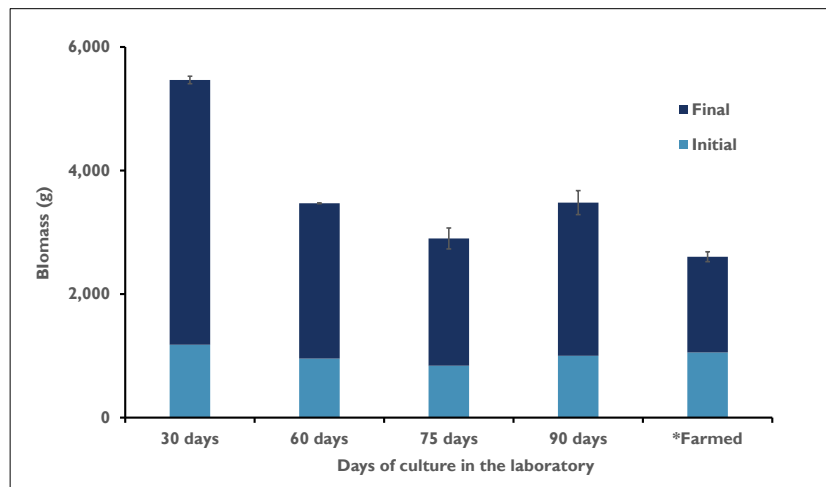
Seaweed

Seaweed is a very important commodity primarily utilized as food and as a source of carrageenan. A laboratory technique used to mass produce seaweed seedlings is micropropagation which usually takes 90 days prior to stocking the seaweed *Kappaphycus alvarezii* in sea cages. A study was done to shorten the laboratory period from the usual 90 days of micropropagation in the laboratory. A tank acclimation step was also tested to reduce mortalities due to environmental shock when directly stocking in cages. After a first run, results show that reducing the laboratory step to 30 days and incorporating tank acclimation resulted in better survival and growth at the sea cage nursery stage. Survival and growth were better compared to seaweed grown for 60, 75, and 90 days. At the grow-out stage, seaweed from the 30-day laboratory step also gave better biomass and growth. A second run will be completed in 2022.

A separate study is being done to improve the survival of seaweed propagules/plantlets, reduce the cost of producing propagules in sea-based nursery cages, and eventually distribute quality propagules to farmers. Toward this, an experiment is currently being done on the use of commercial disinfectants for seaweeds affected by the filamentous algae and ice-ice disease. Another ongoing experiment is comparing the growth performance of



Tank acclimation of micropropagated seaweeds prior to stocking in sea cages and outplanting to farms



In a first run, reducing the seaweed laboratory period to 30 days and incorporating a tank acclimation stage resulted in better growth at the sea nursery and grow-out stages

SEAFDEC/AQD's tissue-cultured plantlets with farm-sourced seaweeds.

Sandfish

Sandfish *Holothuria scabra*, is an important tropical sea cucumber species but its wild population has been rapidly declining since the late 80s because of overfishing to meet its high global demand. Sandfish hatcheries have been established to enable the farming of the species, but they suffered from very low survival of about 1% annual average. Since 2018, SEAFDEC/AQD

was able to increase survival to about 3% (6.2% max), but problems with environmental conditions and nutrition still need solutions.

In 2021, the tank aeration system and the culture of brown algae *Chaetoceros calcitrans* at the sandfish hatchery were improved. Meanwhile, broodstock collection was very limited due to COVID-19 travel restrictions. In a side-study on the use of SEAFDEC/AQD's concentrated algae to feed sandfish, it was shown that live *C. calcitrans* still fared much better than flocculated and centrifuged *C. calcitrans*.

Alternative natural food

Mudworm

A study is being done to demonstrate the feasibility and profitability of indoor tank-based polychaete (*Marphysa iloiloensis*) culture. Refinements in the culture protocol for polychaete production have been made by defining the appropriate feeding rate and sediment depth required in producing sufficient polychaete biomass. The best polychaete survival and biomass was noted when 50 g/m² feeding rate and 3–5 cm sediment depth were used in polychaete culture

from early juvenile to adult. However, both survival and biomass of adult *M. iloiloensis* were significantly higher when 100 g/m² feeding rate was used.

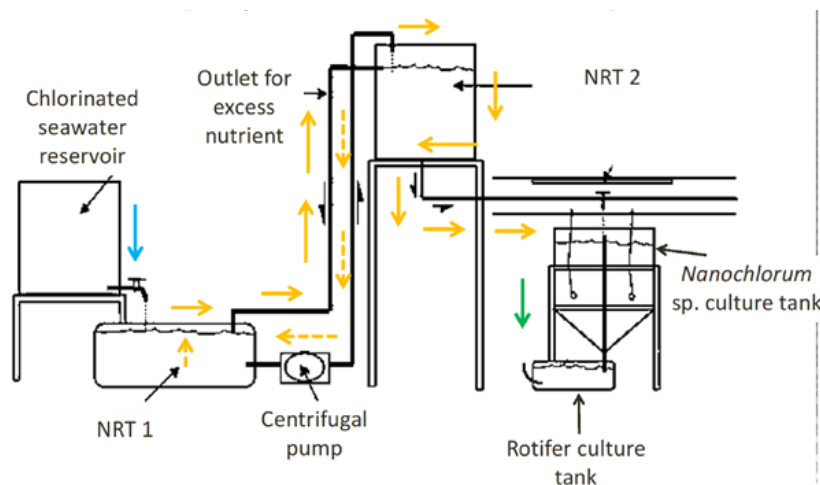
Larval food

A modified continuous culture system is being developed for the mass production of *Nanochlorum* sp. and *Brachionus rotundiformis*. In 2021, the presence of ciliates in the *Nanochlorum* culture system were encountered addressed by way of a bleach assay experi-

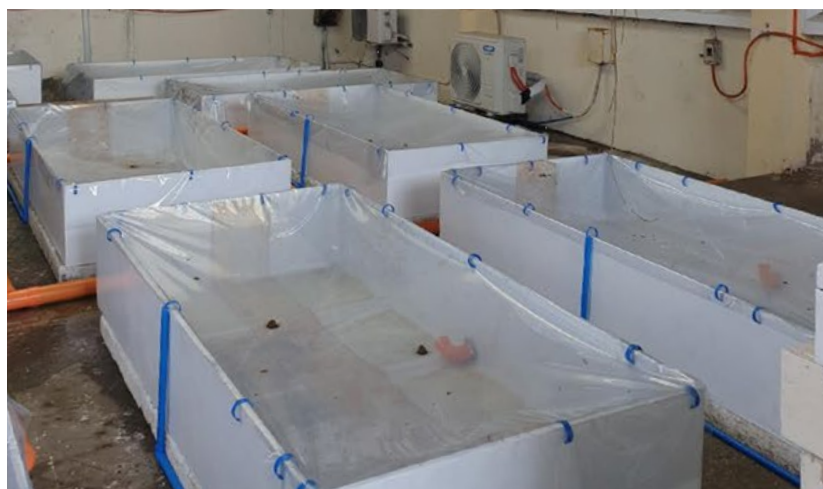
ment where the algal culture was subjected to three different treatments (1 µl bleach, 10 µl bleach and 100 µl bleach) to rid the system of ciliates. Based on the run, a 1 µl bleach treatment is effective in keeping the cell density of *Nanochlorum* at a relatively high and steady level compared to the other treatments. Other activities will continue through 2022.

Rotifer

The use of the rotifer *Proales similis* as the first food for small-mouthed marine fish larvae is being explored. To this end, mass production schemes for of *P. similis* is being developed. Sufficient *P. similis* were obtained from an initial 80 L (containing 4.2 x 10⁶ *Proales* ind/ml) to 180 L (1.37 x 10⁸ *Proales* ind/ml) when a production protocol using centrifuged algal paste was used. Infestation of the *P. similis* stocks by ciliates was observed, but ciliate-free culture was done through isolation of individual *P. similis* followed by gradual scale up. No presence of ciliate contaminants was observed up to 250 ml. Ciliate presence was inevitable at higher volumes but greatly reduced.



Schematic diagram of proposed modified continuous culture for *Nanochlorum* sp. and *Brachionus rotundiformis*



Experimental tanks for the culture of harpacticoid copepods *Tigriopus* sp.

Copepod

A study is being done to develop a large-scale culture protocol for harpacticoid copepods (*Tigriopus* sp.) which are a potential food in marine fish larvae. Results of the production trials showed that the highest copepod population growth was recorded at a peak of 200,000 individuals when 10 ml biofloc concentration was used. The suitability of *Tigriopus* as fish larval food shall be evaluated in 2022.

Verification & demonstration

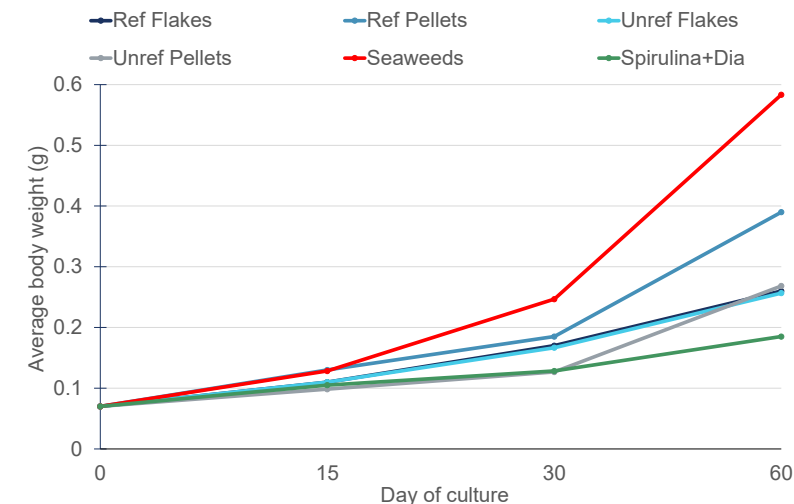
Abalone

The hatchery production of donkey's ear abalone (*Haliotis asinina*) juveniles is being demonstrated while verifying the efficacy of different diets on the reproductive performance of broodstock, and the growth and survival of abalone juveniles.

From January to September 2021, 128,942 abalone juveniles (3–5 mm) were produced in the abalone hatchery. Average survival rate from veliger stage larvae to early juvenile stage was 1.99%. Abalone broodstock fed a formulated diet were observed to spawn twice yielding 640,000 veliger larvae. Seaweed-fed broodstock spawned 4 times and produced 1,610,000 veliger larvae. When different types of artificial diets (refined flakes, unrefined flakes, refined pellets, unrefined pellets) and natural food sources (seaweeds, *Spirulina* + diatoms) were given to abalone juveniles, those fed seaweeds had the highest average body weight (ABW) followed by the juveniles fed refined pellets. The least ABW was noted in the juveniles fed *Spirulina*+diatoms. Further trials are underway.

Mangrove crab

Mass production of crab instars is continuously being done at SEAFDEC/AQD to support in-house research projects and to provide the need of nursery and grow-out pond operators. A total of 687,500 mangrove crab instars were produced in the hatchery in 2021 of which 451,840 were disposed to research project and buyers from the Philip-



Preliminary data on growth of abalone juveniles fed different types of diet including refined (ref) flakes, refined pellets, unrefined (unref) flakes, unrefined pellets, seaweeds, and *Spirulina* with diatoms (dia)

pinas. Meanwhile, 23,400 megalopa were used for research projects. Out of a total of 265 broodstock collected from various sources in the Philippines, 32 spawned and 14 hatched. Some broodstock collected did not spawn, others were positive for WSSV and were discarded, and 242 died prior to spawning despite disinfection procedures.

Giant freshwater prawn

SEAFDEC/AQD aims to promote the culture of the giant freshwater prawn in Western Visayas (Philippines) by demonstrating the efficient production of seed, profitability of the venture, and bolstering the local supply of postlarvae. In 2021, the multi-species freshwater hatchery at the Tigbauan Main Station continued to operate, producing 78,557 postlarvae that

were used for in-house studies and the rest distributed to buyers from Capiz, Iloilo, and Negros Occidental. Production will be scaled up in 2022 to meet the numerous inquiries and requests from local farmers.

Seaweed

A production study is being done to increase the production of seaweed propagules through micropropagation in a land-based nursery and determine the economics of micropropagule production in the land-based nursery. *Kappaphycus alvarezii* were sourced from Caluya and Pandan, Antique. As of August 2021, the nursery produced 38,659 propagules with an average survival of 77.3%. However, sourcing of explants was hindered by COVID-19 restrictions.



HEALTHY AND WHOLESOME AQUACULTURE

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

Aquaculture Nutrition

Culture of pompano in cages

Snubnose pompano (*Trachinotus blochii*) is well suited to cage culture because of its fast growth rate and excellent meat quality. To improve profitability, a study was done in 2021 to optimize the feeding rate. Four feeding rates were tested for 103 days of grow-out culture in cages at the Igang Marine Station. High feeding rates yielded the best growth. However, feed conversion ratio was also much higher and significantly lower with lower feeding rates. Growth indices are also higher when the fish are fed diets containing fish meal compared to formulations with blends of plants and animal by-products.

Cost-efficient alternative ingredient blend

To come up with a cost-efficient formulation for pompano grow-out in sea cages, fish meal protein in formulated feeds was replaced with various blends of alternative protein sources. Soybean meal, corn protein concentrate, protein enhanced copra meal, poultry by-product meal, and hemoglobin meal were blended into four different formulations and compared to a completely fish meal-based diet. After 90 days of pompano culture in cages, it was found that the diets with alternative protein ingredients performed poorly compared to the formulated diet that was completely based on fish meal. In another experiment, corn protein concentrate was used to replace fish meal and enzymes were added. This experiment will continue in 2022.

Fungi-fermented feed ingredients as alternative protein source

Grains, seed meals, and leaf meals are potential protein sources for aquafeeds to substitute for the expensive and unsustainable fishmeal. However, these are underutilized because of their lower protein content compared to fish

meal, high fiber content, and the presence of anti-nutritional factors (ANFs). Solid state fermentation (SSF) using filamentous fungi is a cost-effective way to increase protein content, reduce fiber, and remove ANFs of plant-derived feed ingredients.

A total of 12 feed ingredients were processed and fermented using spores of the fungi *Aspergillus oryzae* for five days. Results show fermentation with *A. oryzae* can

Growth parameters of pompano grown at different feeding rates

Treatment	Feeding rate	Survival (%)	Initial ABW (g)	Final ABW (g)	% Weight Gain	FCR
High Feed Rate	5-6%	97.04	61.0	350.37	474.38	3.97
	4-5%	98.32	63.0	325.47	416.62	3.44
Low Feed Rate	3-4%	97.36	70.5	287.59	307.93	2.42
	2-3%	96.76	71.0	191.19	169.29	2.06



Harvest of pompano in cages at the Igang Marine Station

significantly improve protein levels of the feed ingredients tested, except for *Ulva* algal meal and *Azolla* meal. Fine-tuning of the fermentation process is ongoing and feeding experiments will be done in 2022.

Production techniques for culture of silver therapon

Silver therapon (*Leiopotherapon plumbeus*) is an endemic freshwater fish in the Philippines and regarded as one of the most valuable edible native freshwater species. SEAFDEC/AQD has been developing domestication techniques for the fish to conserve its natural population which has been dwindling due to intense fishing pressure. Growth and feed utilization experiments were done in 2021 using two formulated diets and two feeding rates in nursery rearing. Diets did not have an effect in growth, survival, and feed conversion ratio (FCR) in tank- and lake-based cages. Meanwhile, a higher feeding rate resulted in elevated FCR. In another experiment to define the dietary protein requirement of fingerlings, it was found that the optimum protein level in feeds was 35%. Experiments will continue in 2022.

Polyculture of tilapia and giant freshwater prawn in biofloc

Biofloc technology is an approach that promotes sustainable food production by minimizing feed cost and waste products. A study is being conducted to evaluate the efficiency and profitability of Nile tilapia-giant freshwater prawn polyculture using a biofloc system at different feeding rates. Preliminary results in pond trials showed better weight gain of tilapia

Changes in protein levels of feed ingredients after static fermentation with *Aspergillus oryzae*

Feed Ingredient	Protein Level (% dry matter)		Rate of increase (%)
	Unfermented	Fermented	
<i>Gliricidia</i> (madre de cacao) leaf meal	23.57	26.86	13.96
<i>Tricanthera</i> (madre de agua) leaf meal	17.02	18.93	11.24
<i>Leucaena</i> (ipil ipil) leaf meal	36.04	39.24	8.88
Cassava leaf meal	31.03	35.77	15.27
<i>Ipomoea aquatica</i> (water spinach) leaf meal	31.65	35.03	10.69
Soybean meal	53.19	57.20	7.54
Corn meal	7.53	8.30	10.27
Rice bran	13.47	15.00	11.36
Wheat flour	12.08	13.39	10.85
Corn starch	0.27	0.33	25.00
<i>Ulva</i> sp.	22.36	20.57	-7.98
<i>Azolla</i> sp.	23.12	23.54	1.85



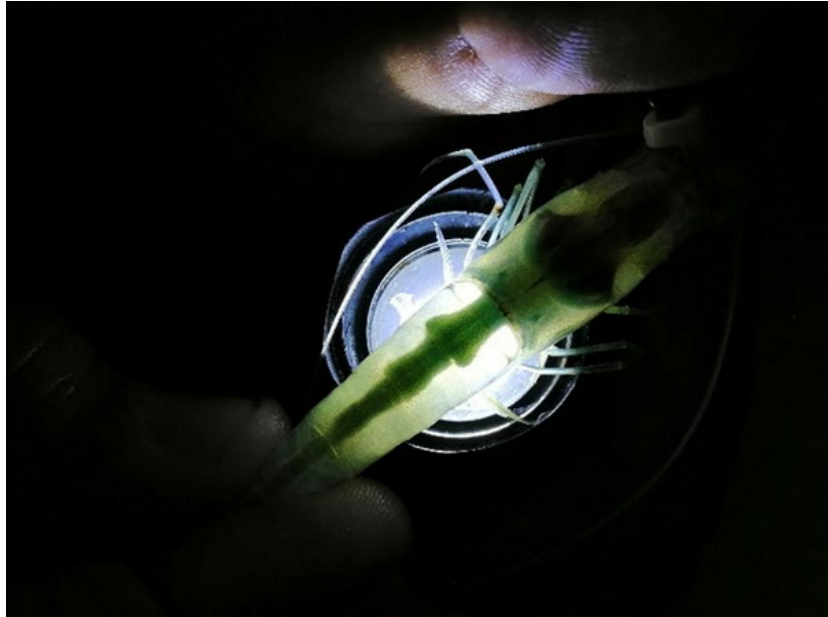
Clockwise from top left: *Tricanthera* (madre de agua) leaves, *Gliricidia* (madre de cacao) leaves, *Azolla*, and *Ulva* leaves used as alternative protein sources

pia in polyculture with the giant freshwater prawn compared with the traditional culture. However, growth of the giant freshwater prawn was better in the traditional culture. More runs will be done in 2022.

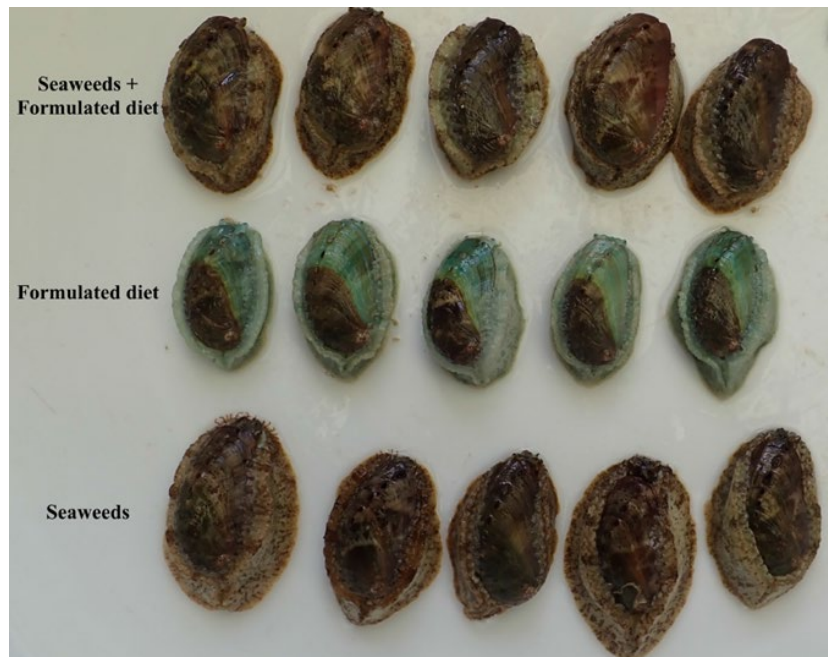
Improvement of white shrimp reproductive performance

Optimal nutrition has been shown to improve the reproductive performance of shrimp. However, effective diets are mostly fresh squid, bivalves, and polychaetes. To overcome the limitations of fresh diets, a study was done to develop formulated broodstock maturation feed for the white shrimp (*Penaeus indicus*) that is comparable with fresh diets. One strategy is to include polychaete extracts in the formulation to speed up gonad maturation and improve the shrimp's sperm quality.

Results show that the inclusion of at least 0.25% polychaete polar lipid fraction (PLF) can increase broodstock gonad maturation by 20% compared to those fed with basal and control fresh diet. At the same PLF inclusion, a 4.4-fold increase in the relative expression of vitellogenin mRNA was also determined. Meanwhile, the polychaete total soluble and neutral lipid fractions were the more effective diet supplements to improve sperm counts of male broodstock.



Mature ovaries of *Penaeus indicus* broodstock fed diet supplemented with polychaete extracts



Abalone fed different diets at six months after stocking

Natural and formulated feeds for abalone

The grow-out of abalone is still dependent on the seaweed *Gracilariaopsis heteroclada*, the natural diet of the mollusk. Unfortunately, the supply of the seaweed is limited. SEAFDEC/AQD has long developed formulated feeds for abalone

(*Haliotis asinina*), but recently focus is being given to lowering the cost to improve the profitability of abalone farming.

Nine different diets, including seven new formulations, underwent preliminary testing for stability, composition, cost, and growth

performance of abalone. An unrefined flake diet was chosen considering all criteria. Six months after stocking, the best growth was achieved in abalone fed a mix of seaweed and formulated diet, followed by those fed with seaweeds only, and lastly those fed the for-

mulated diet only. Survival was highest in abalone fed with seaweeds only, followed by those fed a mixed diet, and lastly by those fed a formulated diet only. Field culture will be done in 2022.

Refined formulated feed for mangrove crab

Conventional feeds used in mangrove crab culture are fish by-

catch and slaughter waste products. These kinds of feeds, however, easily spoil water quality and may carry disease agents that affect crabs. They are also prone to supply fluctuations and spoilage. To resolve this, a refined water-stable formulated feed for mangrove crab was developed and tested in juveniles in various combinations with fish bycatch. After 90 days of culture, crabs fed with the refined formulated feed

alone performed best. Growth performance declined with increasing proportions of fish bycatch given (25%, 50% fish bycatch), but these were still better than those fed only a commercial feed. Crabs fed with fish bycatch alone performed very poorly and did not survive after 90 days of culture.

Aquatic Health Management

Detection, control, and treatment of catfish pathogens

Sporadic mortalities in pond-cultured African catfish (*Clarias macrocephalus*) have been observed by farmers in Iloilo, Philippines. A study to monitor and do surveillance of the disease-causing agent was set up. Isolates from catfish hatcheries and nurseries were examined to identify the bacteria present. A total of 19 species of bacteria were observed in the hatchery and 26 species in the nursery. Fifteen have already been sequenced. The study also found that catfish eggs in the hatchery did not hatch due to high water hardness.

Tilapia Lake Virus detection, quantification, and viability

In 2009, a novel virus named Tilapia Lake Virus (TiLV) caused mass mortalities of farmed tilapias in Israel and Ecuador and has since then been reported in many countries. To support efforts to monitor the virus, a molecular detection technique was developed

to specifically detect TiLV. A duplex semi-nested protocol was developed and tested in the field. The protocol may be used in fish samples but may not work for environmental samples such as water, soil, and sediments. The project determined that TiLV can be found in various areas in the Philippines in different types of environments such as the wild, in ponds, and floating cages. TiLV can infect all developmental stages of tilapia from fry to adult which may exhibit disease signs or may be asymptomatic.

Vaccination of cage-cultured marine fish

Nervous necrosis virus, the causal agent of the disease viral nervous necrosis (VNN), has been implicated in high mortalities of farmed marine fish species. SEAFDEC/AQD has developed a vaccine against VNN but it still needs verification in the field. A total of 81 assorted marine fish, including pompano broodstock, were booster vaccinated against VNN in 2021, out of the 93 that received primary vaccination in 2020. In 2021, 256 marine fishes received primary vaccination against VNN.

Milt, eggs, and spawned eggs from vaccinated and unvaccinated pompano broodstock were negative for NNV according to RT-PCR results. NNV detection in milts, eggs, and spawned eggs collected from both vaccinated and unvaccinated pompano broodfish is ongoing. No incidence of abnormality/mortality is observed among offspring currently being reared at the Tigbauan Main Station hatchery. Vaccination of high-value fish broodstock in cages and land-based tanks will continue in 2022.

Control of pompano sea lice infestation

Currently, sea lice (Caligidae) infestation is the most significant disease problem affecting pompano reared in cages and tanks. The efficacy of emamectin benzoate as an in-feed treatment for pompano was demonstrated in 2020. In 2021, the efficacy of hydrogen peroxide and freshwater bath to control sea lice in pompano was demonstrated. In a first run, sea lice prevalence decreased on the third day after treating pompano with freshwater (80%), 1500 ppm hydrogen peroxide (65%), and 2000 ppm hydrogen peroxide (45%). Prevalence in un-

treated groups remained at 100%. Confirmatory runs will be done in 2022.

Seaweed disease and pest detection

The seaweed industry is beset by various diseases and pests resulting in the decline of seaweed production. The study established key diagnostic tools (detection protocols and molecular diagnostic tools) for yield-limiting seaweed diseases and pests (e.g. epiphytes and endophytes). The tools include histology, electron microscopy, and polymerase chain reaction. An epiphytic filamentous algae collected in Iloilo was identified as *Melanothamnus thailandica* which is possibly a new epiphyte affecting farmed seaweeds in the Philippines. Together with other researchers involved in the project, a seaweed brochure was produced entitled Farm Management and Biosecurity Measures of Eucheumatoids: cultivars, pest and diseases, risks and risk managements. The brochure is available in English and three Philippine languages (Tagalog, Bisaya/Cebuano, Tausug). Two posters entitled Commercially Farmed Eucheumatoids and Major Problems in Eucheumatoid Farms are due for printing and distribution.

Catfish farm's production surges after easy fix



SEAFDEC/AQD experts assisted a catfish farm in Zarraga, Iloilo, Philippines to solve its problematic production of catfish fry. After SEAFDEC/AQD helped resolve a problem with their water source, the farm produced an all-time high of 500,000 catfish fry per week in January 2021.

The farm was one of the many hatcheries struggling to keep up with the demand for catfish seeds, especially that most of their collected eggs fail to hatch while surviving fry die before they can be sold to other farmers. In early 2020, the hatchery produced just 60,000 fry per week, but even then, production began to decline in June 2020 when eggs failed to hatch, leading the operator to seek assistance from AQD.

AQD dispatched a team composed of a chemist, a fish biologist, microbiologists, and engineers to holistically evaluate the hatchery operations. It was found that the facility's water source had very high hardness and affected the hatching of catfish eggs.

One of the deep wells that served as the farm's primary water source reached hardness levels as high as 500 ppm (parts per million) when water hardness levels for egg hatching should ideally be between 30 and 60 ppm. Upon the advice by SEAFDEC/AQD experts, rainwater was mixed with water from a deep well to reduce the water hardness level in the hatching tanks.

Since then, no further problems were encountered in the hatchery and the facility produced record-breaking numbers of seeds. With AQD's advice, the hatchery also upgraded its biosecurity by disinfecting breeders and eggs after each induced spawning session. A more consistent monitoring of water parameters also began to be done.

MAINTAINING ENVIRONMENTAL INTEGRITY

An aerial photograph of a coastal area with clear, turquoise water. Several large, circular aquaculture pens are visible, each containing a few people. A long, narrow pier or walkway extends from a rocky shore in the bottom right towards the center of the image. The water is shallow and clear, showing some underwater vegetation. The sky is not visible, as the image is a top-down view of the water and shore.

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.

Strategic feeding of milkfish

With feeds accounting for 70% of operational expenses in milkfish cage culture, strategies to reduce feed cost will have significant impact. One way is to take advantage of compensatory growth (CG) wherein fish grow rapidly after a period of food restriction. However, defining the optimal period of food restriction is important as too long or too short will result in irreversible stunting of growth or failure to stimulate compensatory growth.

Based on preliminary work since 2019, feeding schemes were designed and tested in grow-out cage culture of milkfish in 2021. Results confirm that feeds can be strategically given to utilize the natural compensatory growth mechanism in milkfish during its grow-out in marine cages. So far, results suggest that repeated cycles of 3 days starvation and 12 days of refeeding can potentially reduce feed input by up to 20% while still achieving a harvest volume comparable to continuous feeding.

Community-based sea cucumber production

Sea cucumber (*Holothuria scabra*) mariculture offers livelihood opportunities for coastal communities throughout Southeast Asia. Hatchery and field culture methods have been previously developed with support from the Australian Centre for International Agricultural Research (ACIAR). The improvement of technical skills and the reliability and efficiency of these methods to support community-based sandfish culture in Viet Nam and the Philippines is currently being done.

In 2021, imported and locally available algal concentrate prod-

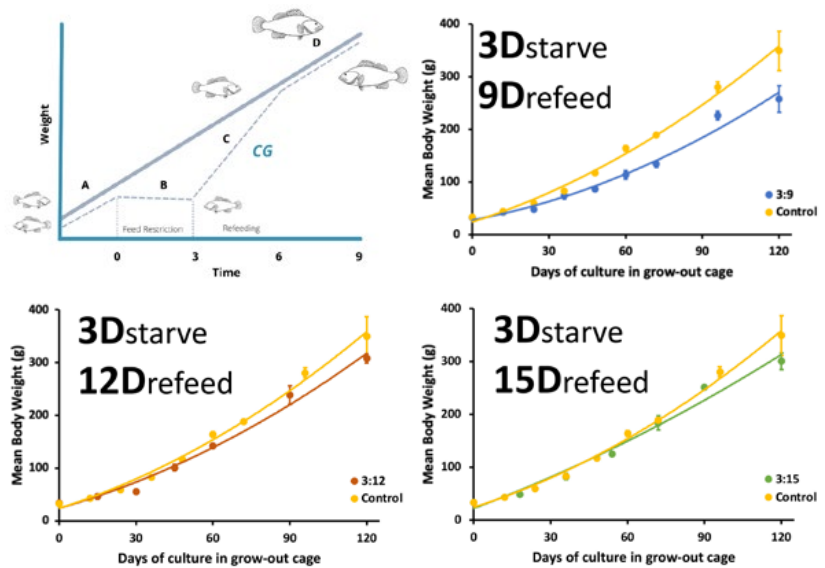


Illustration of compensatory growth (CG) in fish showing weight gain over time (top left) and actual growth of milkfish in cages subjected to different combinations of starvation and refeeding



Predation experiment for sea cucumbers, with high and low net enclosures

ucts were tested in the hatchery as food for larval sandfish. It was found that a diet of live *Chaetoceros calcitrans* was still better, but two imported brands of concentrated algae (*Isochrysis* and a diatom mix) may be acceptable alternatives. Further trials will be done in 2022, including the evaluation of

SEAFDEC/AQD's *C. calcitrans* concentrate being the best-performing locally available product during initial testing.

In another experiment, the likelihood of predators preying on the sandfish was evaluated in a field experiment that compared two pen designs. In general, growth of

sandfish was better in pens with a higher net enclosure that excluded predators compared to pens with a low net wall that allowed predators in. After 15 months, the higher pens also had much better sandfish survival (80%) than the low pens where no sandfish survived. In areas where the potential for predation is high, rearing sandfish in pens with high net walls can improve growth and survival rates.

Analyses of sediment characteristics and biophysical parameters will continue in 2022, as well as testing other potential predator-mitigation strategies.

Fish-prawn co-culture in tanks and lake cages

Despite the potential to boost farm yields, the co-culture of genetically enhanced seedstock, such as tilapia, along with other low-input species, such as prawns, have not been fully utilized in local small-scale aquaculture. A study was done to jointly produce genetically-improved Nile tilapia or red tilapia hybrids, together with giant freshwater prawns in tanks and lake-based cages.

Results from the tank experiments showed that I-EXCEL Nile tilapias, with an average weight gain (AWG) of 181.6–239.4 g, have better growth performance compared to red tilapias (110–143.7 g AWG), reared in monoculture or in co-culture with prawns especially during the wet season. In terms of survival, red tilapias (76.7–95%) have a slight advantage, though not significant, compared to the I-EXCEL Nile tilapias (75–90%), especially when co-cultured with prawns. Based on overall production traits, experimental runs conducted during the dry season were better than during the wet season. For the tilapia-prawn co-culture part of the study, good results were obtained when using low-stocking densities of 10/m² and 7.5/m² for tilapias and prawns, respectively under favorable water quality conditions.

In a separate experiment, three feeding schemes were tested in lake cages: only tilapias were fed, only prawns were fed, and both tilapia and prawn fed. Results showed that in the treatment where only tilapias were fed, tilapias grew at rates that are comparable with those where both tilapias and prawns were fed.

Interestingly, even when unfed, the prawns grew to marketable size, gaining an average of 32.3 g in five months.

Considering the performance of all test species, the study showed that red tilapias stocked at 10/m² in net cages set inside tanks with prawns (7.5/m² stocking density) can grow and survive well with prawns even when only the red tilapias are fed since the prawns grew and survived at higher rates. Although prawn growth was not quite optimal, the co-culture of prawn using the recommended set-up is still technically viable for fish farmers to adopt.

Integrated Multi-Trophic Aquaculture

Growing aquatic organisms from different trophic levels together in one system harnesses the potential for one species' wastes, such as uneaten feed, feces, and other metabolic products, to serve as input for the other species in the same system. This approach potentially minimizes its environmental impact while maximizing the use of feed inputs. In collaboration



Tilapia and prawn co-culture setup in tanks (left) and lake cages (right)

with the Japan International Research Center for Agricultural Sciences (JIRCAS), a combination of fed fish (milkfish), a deposit feeder (sea cucumber), and plants (seaweed) were tested in an Integrated Multi-Trophic Aquaculture (IMTA) pen set-up.

The experimental IMTA set-up design has evolved since 2015 to address various problems encountered respective of the species. The traditional 2D IMTA, where all commodities occupy the same pen, was found to be problematic especially at low tide where the swimming space for fish became limited because of the seaweeds, while feed waste was too much for the sandfish. The 3D IMTA, where seaweeds and sandfish were cultured adjacent to the primary fish pen showed promise. Seaweeds proliferated but showed significant seasonality and mortality was high due to predation by herbivores. On the other hand, sea cucumbers (sandfish) have consistently shown good growth but were stunted after 4–5 months. In a 4D IMTA, stunted sandfish were re-stocked inside the primary fish pen to feed on remaining organic materials after harvest of the milkfish.

Experimental demonstration of IMTA from 2011 to 2018 showed that milkfish in this IMTA set-up produced marketable sizes at harvest. However, because of the small-scale and the open pen system, there was no clear significant bioremediation effect from sandfish and seaweed. In the recent culture trials in 2020 and 2021, the IMTA pen showed to be better as a nursery system for sandfish, than as a grow-out system.

Consolidated results of the project will be published in 2022 in the form of workshop proceedings.



Top view of the experimental-scale Integrated Multi-Trophic Aquaculture set-up at Pandaraonan, Guimaras, Philippines



Monitoring of the Integrated Multi-Trophic Aquaculture set-up at Pandaraonan, Guimaras, Philippines

MEETING SOCIAL AND ECONOMIC CHALLENGES



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

Community-based sea cucumber farming

Sea cucumbers are consumed and traded in Asian markets as a high-value delicacy and part of traditional medicine. The growing demand for its products led to the depletion of its wild stocks. Mariculture may help rebuild sea cucumber stocks via deliberate culture-based restocking or as a by-product of sea ranching. It may also be an economically and ecologically sustainable supplemental livelihood for coastal fishing communities.

As part of a long-term program supported by the Australian Center for International Agricultural Research (ACIAR), a SEAFDEC/AQD project aims to develop sea cucumber (*Holothuria scabra*) culture technologies and demonstrate the feasibility of stocking them in a sea ranch managed by fishing communities to provide them with additional livelihood. Understanding social and economic dynamics is as essential as species biology and ecology. Hence, a study is ongoing to cover the socioeconomic component.

In 2021, all fieldwork activities ceased because of COVID-19 travel restrictions. The Molocaboc Sea Ranchers Association (MOSRA), the fisherfolk partner, continuously monitored and maintained the sandfish culture setup with minimal remote supervision and held regular monthly coastal clean-ups and meetings with the local village officials.

Fishing (67%) was the primary livelihood of MOSRA members. Their monthly income from all livelihood sources for a household size of four was, on average, between PHP 3,140.24 and PHP 4,676.83, below the poverty threshold. Members perceived that sea cucumber



After local stocker trade interview



Information drive on the proper catch size of sea cucumbers through person-to-person campaigns (left) and displaying posters in strategic areas (right)

stocks have declined, with most (60%) saying their catch volume decreased due to an increase in the number of gleaners fueled by the increased market demand for sandfish.

More than three-fourths (79%) of MOSRA members are gleaning sea cucumbers which is a substantial part of their livelihood, particularly during typhoon season. As recounted by local stockers on the island, the pandemic intensified

the gleaning of undersized sandfish by women and children. Therefore, education, information, and communication (EIC) were conducted at Molocaboc Island mainly to promote the gleaning of only bigger (>320g) sandfish. Initial EIC was made with the industry players, community members, and local officials on the island through face-to-face discussions, infographic posters, and flyers.aa

An aerial photograph showing a vast expanse of flooded agricultural land. A long, straight road or canal runs diagonally from the bottom left towards the top right, cutting through the water. The water is a murky brown color, and the surrounding fields are mostly submerged, with only some trees and small structures visible above the surface. The sky is overcast with grey clouds.

ADAPTING TO CLIMATE CHANGE

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

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

To ensure the sustainability of aquaculture amid the threats of climate change, SEAFDEC/AQD compiles scientific data and information on the effects of increasing temperature and acidity, as well as other perturbations in the culture environment that affect the growth, survival, and performance of different cultured species. Aside from the inclusion of climate change topics in aquaculture training courses, and the dissemination of relevant developments in climate research, several activities under AQD's Departmental Programs investigate the impact of environmental variations on aquaculture organisms.

Research has previously described how environmental parameters affected the growth, reproduction, and survival of farmed commodities in different stages. Rabbitfish (*Siganus guttatus*) and mangrove crab (*Scylla serrata*) broodstock were observed to experience low spawning during seasons with elevated temperatures of 31 °C to 33 °C. Meanwhile, a series of experiments showed that female abalone (*Haliotis asinina*) breeders failed to survive by day 45 at 33 °C,



Climate change impacts may include sea level rise which, when compounded with more severe weather events, could severely affect coastal aquaculture facilities. Shown here is a storm surge threatening the seawall of the Tigbauan Main Station of SEAFDEC/AQD.

while only a ratio of males survived by day 60. However, 80% of the abalone survived when exposed to a more ambient temperature. Lower egg hatching of milkfish, Asian sea bass (*Lates calcarifer*), and rabbitfish (*Siganus guttatus*) at 30 °C was also observed. In the larval stages, mangrove crab and rabbitfish reared at 33 °C experienced low survival. In the grow-out of tilapia, lower survival was also noted in lake-based cages, where temperatures reached up to 33.2 °C, compared to tilapia in tank-based cages with lower average temperature.

Along with increasing sea surface temperatures, climate change is also expected to affect the pH lev-

el of rearing water because of the increased concentration of carbon dioxide in the atmosphere. The production of natural food is affected by a low pH level. Rotifers and copepods (*Pseudodiaptomus annandalei* and *Acartia tsuensis*) population growth was found to be lower when at pH 7.5. The average pH of the ocean is currently at 8.1.

Aside from these research findings, SEAFDEC/AQD's Tigbauan Main Station has observed the impacts of sea level rise which, when compounded with more severe weather events, could severely affect coastal aquaculture facilities.

REGIONAL PROGRAMS FISH HEALTH & SUSTAINABLE AQUACULTURE



With support from the Government of Japan, information on aquatic health management continued to be produced through research and disseminated through trainings. Research projects on new aquaculture species, alternative feeds, and socioeconomic strategies were likewise pursued.

Sustainable aquaculture

Community-based hatchery, nursery, grow-out of giant freshwater prawn

The farming of the high-value giant freshwater prawn (*Macrobrachium rosenbergii*) holds good potential to improve the income of inland fishing communities. However, widespread adoption of the prawn as an aquaculture species is hampered by the lack of juveniles to supply grow-out farms. SEAFDEC/AQD aims to develop community-based strategies to mass-produce giant freshwater prawn postlarvae to supply grow-out operators in Laguna lake and its tributaries.

Social preparation and formulation of local policies & governance strategies were done in 2021. The Pipindan Aquaculture Producers Association (PAPA) was organized with concurrence of the local government, and officers were elected. Validation of baseline surveys done in 2020 was also done based on the bottom-up approach for community-based projects. As part of

the surveys, the reduction of respondents' incomes by 26% due to the pandemic was noted. The structural design of the community hatchery to be built in Binangonan, Rizal was also completed in 2021. Training of fish farmers was delayed because of COVID-19 restrictions. Construction of the small-scale hatchery and training activities are hoped to commence in 2022.

Promoting alternative feeds for freshwater aquaculture

To reduce the cost of feeds, especially for small-scale freshwater farmers, SEAFDEC/AQD aims to develop alternative feed formulations and feeding strategies. Replacement or reduction of fishmeal and other expensive conventional ingredients with the use of alternative protein sources for fish and shrimp diets, such as aquatic weeds, invasive alien species, microbial biomass, and fish by-products, may help in reducing feed costs as it provides affordable options in fish feed formulations.

Two alternative feeds and feeding strategies were tested for Nile tilapia fingerlings reared in tank- and lake-based cages during the wet season. Diets incorporating bacteria-treated (BOM) and yeast-treated (YOM) okara meal were tested across daily and alternate-day feeding strategies. After 12 weeks of culture, the diet type affected the growth and feed utilization of tilapia in tank trials but not in lake trials. In tank trials, diets with BOM have significantly higher mean final weight, percent weight gain, specific growth rate (SGR), and final yield. Meanwhile, feed conversion ratio (FCR) was significantly higher in groups fed diets with yeast-treated okara meal (YOM). In both trials, daily feeding resulted in higher mean final weight, percent weight gain, specific growth rate, and final yield. Meanwhile, alternate-day feeding resulted in better FCR. Alternate day feeding in tanks returned better survival but did not make a difference in lake trials.

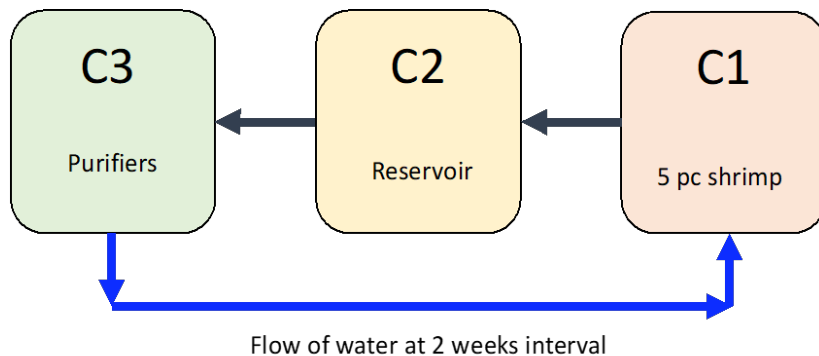
In a separate study, aquatic weeds water hyacinth and water cabbage were used to replace soybean meal in diets for tilapia in a biofloc-based system. After 16 weeks of culture, inclusion levels of the aquatic weeds between 0% and 11% yielded no significant difference in terms of mean body weight, weight gain percentage, and SGR. High survival of 91% to 98% was observed in all cases. Biometric indices likewise did not show significant differences. More feeding trials using other alternative ingredients will be done in 2022.



Meeting of Pipindan Aquaculture Producers Association officers



Water hyacinth (top) and water cabbage (bottom) used as soybean meal replacement in tilapia feeds



Experimental schematic design of the microcosm experiment

Ecosystem approach to responsible and sustainable shrimp farming

To help minimize and mitigate the occurrence of diseases in shrimp farming, two ecosystem approaches for small-scale farmers are being examined. The first is to enhance the purification of rearing water by utilizing aquatic organisms. Previous studies have identified seaweeds (*Gracilaria*

sp., *Eucheuma* sp., *Caulerpa* sp., *Kappaphycus* sp.), pickleweed (*Salicornia* sp.), abalone (*Haliotis* sp.), sandfish (*Holothuria* sp.), oyster (*Crassostrea* sp.), and mussels (*Perna* sp., *Mytilus* sp.) as candidates for removing nitrogen from water. These species were tested for their ability to remove ammonia, total ammonia nitrogen (TAN), and phosphate from the environment.

To test the effectiveness of the aquatic organisms to purify the water, a microcosm experiment

was carried using a recirculating aquaculture system to simulate an artificial or constructed wetland. Four sets of interconnected tanks with 3 compartments each were used. The first compartment (C1) is used to culture shrimp while a second compartment (C2) serves as a reservoir that receives water from C1. A third compartment (C3) was used to treat effluent from C1 and C2 and was stocked with either *Holothuria*, *Caulerpa*, or *Gracilaria*. Water flowed from C1 to C2 and C3, and back from C3 to C1 once every two weeks. The experiment continued for two months. Preliminary results indicated that sandfish is the best candidate among the three organisms to treat the water. In the *Holothuria* treatment, the shrimp had higher weight gain, low mortality, and lowest percentage of green *Vibrio* (where most pathogenic *Vibriosis* belong) and *Vibrio parahaemolyticus*, causative agent of acute hepatopancreatic necrosis disease (AHPND). The microcosm experiment will be replicated more times in 2022 and upscaled to an earthen pond setting.

Development of aquaculture techniques for shortfin scad

Shortfin scad (*Decapterus macrosoma*), locally known generally as round scad or "galunggong", is the most important small pelagic fish species in the Philippines. This species is usually caught in large quantities and is the main source of inexpensive animal protein for lower income groups in the Philippines. However, a decrease in the volume of fishery production of shortfin scad has been observed in the last five years which may be due to overfishing.

In 2021, a total of 216 shortfin scad samples were collected from the wild in February to October. All shortfin scad samples were measured to determine body weight and length, number of females, males, and juveniles (undetermined). A total of 87 females, 99 males, and 30 juveniles were collected and dissected to determine data on body weight and length, reproductive biology including fecundity, oocyte diameter, gonadal maturity and feeding habits.

Transportation trials were done by packing in oxygenated bags and customized transport tank with chiller, with a second transport trial incorporating 32 hours pre-transport conditioning in hapa nets. Shortfin scad that were finally stocked in flow-through broodstock tanks were fed live mysids, *Acetes*, and anchovy fry starting one day after transport.

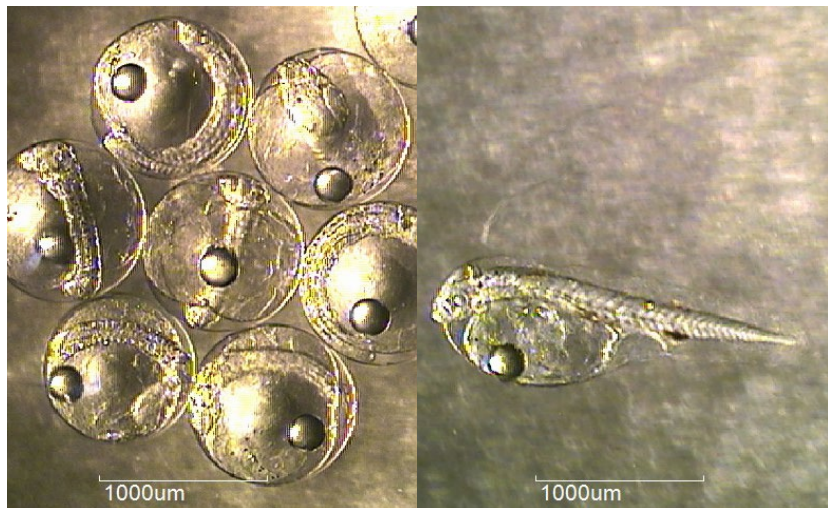
Broodstock collected in August and October began laying eggs in December (see front inside cover), commencing trials on egg hatching, feeding management, rearing management, and observations on larval development which will be done through 2022.

Development of aquaculture techniques for slipper lobster

The scyllarid lobster (*Thenus orientalis*) is one of the five lobster species commonly traded in the Philippines. It is sought after as a seafood delicacy with a good price in the local market ranging from US\$ 9 to US\$ 15 per kilogram. The slipper lobster is caught by commercial trawls or speared by divers, the latter remarking that its wild population has dwindled compared to previous years.



Stocking of wild samples of shortfin scad in holding tanks at Tigbauan Main Station



Fertilized eggs (left) and newly-hatched larva (right) of shortfin scad



Holding tank for slipper lobster broodstock collected from the wild

Three batches of adult slipper lobsters were transported from Sagay City and Escalante City, Negros Occidental to SEAFDEC/AQD's Tigbauan Main Station between April and November 2021. The slipper lobsters were successfully maintained in flow through concrete tanks with mild aeration. Periodic samplings monitored growth, molting, and the presence of eggs. It was observed that the slipper lobster prefers to feed on squid and a small silvery fish, locally called *lobo-lobo* or *dulong*, compared to *Acetes* and mussels.

Spawning episodes were observed in September and October and documented by video in the morning at 5:10 AM. The phyllosomas that hatched were fanned away using the pleopods of the female slipper lobster. Empty egg capsules can be seen still attached to the ovigerous setae, but eventually shed off about 48 hours after hatching. In 2022, trials on egg hatching, feeding, and rearing management will be done alongside observations on the development of hatched larvae.

Development of aquaculture techniques for 'kawakawa'

Mackerel tuna, also known as "kawakawa" (*Euthynnus affinis*) is one of the neritic tunas that is economically important in Southeast Asia. This fish is an important target species for commercial and local fisheries as a substitute for the oceanic tunas. Rapid growth of this species only means that it is potentially attractive as a novel target for aquaculture.

A total of 277 samples of "kawakawa" were collected from February 2020 to August 2021.

Slipper lobster successfully spawned in captivity at SEAFDEC/AQD



Clockwise from top left: Dorsal view of slipper lobster, brown pre-hatching egg mass, fertilized eggs, newly-hatched phyllosoma larvae

Spiny lobsters might be the darling of the lobster farming industry, but farms are still dependent on wild-caught juveniles. Hatchery development is hounded by the spiny lobster's slow growth and complicated larval development. SEAFDEC/AQD is looking at developing hatchery techniques for an alternate species, the slipper lobster *Thenus orientalis*.

Dr. Shelah Mae Ursua, the project leader, says the slipper lobster has shorter larval stages of only 30 days, compared to spiny lobster that takes up to 300 days. Larvae of slipper lobster are also hardier and, at the grow-out stage, its culture period from hatching to reaching market size is 14–16 months, compared to 22–24-months for the spiny lobster.

To breed the lobsters, Dr. Ursua arranged in April 2021 for specimens to be transported from Negros Island to SEAFDEC/AQD's experimental facilities in Tigbauan, Iloilo, an eight-hour journey by land and sea.

By September 2021, egg-bearing lobsters started to hatch their brood. In October of the same year, another milestone was achieved, a slipper lobster fanned out thousands of eggs with its pleopods to facilitate the hatching of phyllosoma larvae in full view of video cameras, vividly documenting its hatching behavior.

The fish were sourced from Antique, using *otoshi-ami*, ring net and hook and line, and Tigbauan, using purse seine. A total of 29 females, 40 males and 208 juveniles (undetermined) were collected and analyzed for basic biological information such as size, reproductive biology including fecundity, measurement of oocyte diameter, gonadal maturity, and gut content. Further refinement of handling procedures will be done in 2022 to improve survival, while monthly samplings will continue.



Dissection of "kawakawa" collected from the field

Aquatic health management

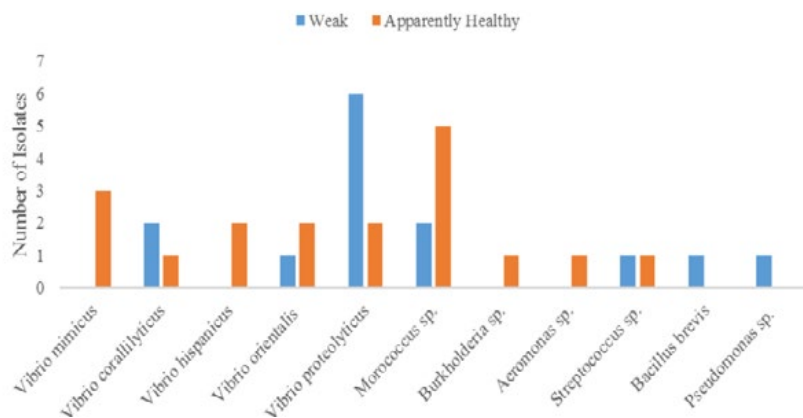
Development of diagnostic procedures for crustacean and fish diseases

Monitoring and surveillance of mass mortalities in aquaculture continued to be done. In January, a follow-up site visit was done in Pontevedra, Capiz to reassess the condition of the farm surveyed in 2020 which exhibited mortalities of mangrove crab, *Scylla serrata*. The farm partially implemented SEAFDEC/AQD recommendations to improve feed quality and observance of good aquaculture practices. Mortalities reportedly continued to occur among the crabs, however, an increase in survival and average body weight was noted.

Bacteriological analysis, biochemical identification of bacterial isolates, molecular diagnosis of diseases, and histopathological analysis were done. Although all the samples from the mangrove crab grow-out farm were PCR-negative to all available PCR detection kits (WSSV, AHPND, IHNV, EHP,



Shrimp samples showing stunted growth, and opaque muscle and hepatopancreas



The bacterial species composition of pure isolates from weak and apparently healthy crab samples (n=32)

and HEMATD), a total of 54 bacterial isolates were isolated and identified from apparently weak crabs. These isolates will be subjected to infection experiments in the latter part of the project since substantial abnormalities were observed in histopathology of the crab tissues.

In 2021, two visits were also made to two *Penaeus vannamei* farms in Zarraga and Ajuy, both in Iloilo that encountered diseases despite strict biosecurity and good aquaculture practices. With proactive monitoring, the Zarraga farm detected WSSV (White Spot Syndrome Virus) at DOC 32. The shrimp completed their culture period with help of close PCR monitoring and application of probiotics and immunostimulants. On the other hand, the Ajuy farm reported shrimp that were PCR-positive for EHP (*Enterocytozoon hepatopenaei*) at DOC 76. Partial harvest was done after the results were received.

Survey of the epidemiology, distribution, occurrence, and prevalence of EHP

Enterocytozoon hepatopenaei (EHP) is a microsporidian parasite that infects the hepatopancreas of shrimps, damaging their ability to gain nutrition from feeds and stunting their growth. Recently, hepatopancreatic microsporidiosis (HPM) caused by EHP has emerged as one of the most important diseases in the shrimp culture industry. The presence of EHP was assessed across seven sampling sites in Iloilo consisting of four farms and three hatcheries. While microsporidian spores were not detected, nested-PCR confirmed EHP

in shrimp from a farm in Ajuy, Iloilo and SEAFDEC/AQD's Dumangas Brackishwater Station (DBS) where prevalence in hatchery-reared and grow-out shrimp is 0% and 7.9%, respectively. Shrimp positive for EHP were found in the first production cycle run depending on the days of culture. In the Ajuy farm, samples in the succeeding second and third production cycle runs were negative for EHP despite the positive infection in the first production cycle run. The average prevalence at DOC when EHP was detected is 37.0% in Ajuy and 13.5% in DBS. In 2022, experiments to understand the transmission of EHP in shrimps will be done.

Investigation of organisms, chemicals and methods to prevent or mitigate shrimp diseases

Penaeus monodon is one of the important species that is widely cultured globally. However, production has decreased due to the occurrence of diseases. Some of the diseases that persistently infect shrimp are caused by the pathogens, such as the Monodon Baculovirus (MBV), Hepatopancreatic Virus (HPV), Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV), White Spot Syndrome Virus (WSSV), *Vibrio parahaemolyticus* causing Acute Hepatopancreatic Necrosis Disease (APHND), and *Enterocytozoon hepatopenaei* (EHP). The pathogens can be transmitted both vertically and horizontally. Chemicals and methods that can disinfect *P. monodon* fertilized eggs and nauplii against pathogens are currently under examination. In particular, electrolysis,

benzalkonium chloride, sodium hypochlorite, sodium chloride, tetraflor, and laundry detergent are being tested as the disinfectants. The search for organisms, disinfectants and chemicals and methods to prevent the vertical and horizontal transmission of shrimp diseases at the hatchery phase will be continued into 2022.

Integrated management of shrimp diseases

In shrimp farming, immunostimulants, vaccines, prebiotics, probiotics, prophylactics, disinfectants, biosecurity, and best management practices have been applied individually or in combination to reduce the incidence of diseases. However, the relative efficacies of each approach or their combinations have not been tested rigorously. To this end, tank and pond trials will be conducted to demonstrate the efficacy of a combination of approaches.

A viability experiment was done in 2021 to check if shrimp samples could be artificially infected by the white spot syndrome virus (WSSV). Round tanks were lined with pathogen-free pond soil and successfully inoculated with WSSV. Simulations of chlorination and drying were conducted, but despite the soil treatment, the tanks were still WSSV-positive. The WSSV detected from the soil was found to be viable and able to infect shrimp as early as 5 days after stocking in the tanks. In 2022, additional simulation trials will be done, and sourcing SPF-shrimp is being considered to come up with a WSSV qPCR-negative stock to test the viability and infectiveness of the virus detected from soil samples.

Capacity Enhancement on Sustainable Aquaculture and Aquatic Animal Health Management

To provide stakeholders in Southeast Asia with the knowledge and skills on various aquaculture technologies, the Government of Japan-Trust Fund provided fellowship grants to a series of aquaculture training courses.

A training course on fish health management served to disseminate knowledge, skills and new approaches in the field. A training on marine fish hatchery was offered twice and covered technologies on broodstock management, spawning and larval rearing of marine fish species such as milkfish, sea bass, groupers, mangrove red snapper, rabbitfish, and pompano. A community-based freshwater aquaculture training was also offered to promote freshwater aquaculture technologies in rural communities in Southeast Asia.

Training Courses in 2021 supported by the Government of Japan Trust Fund

Training Course	Date of Training	No. of participants	GOJ-TF grantees	Participating countries
Distance Learning Course on Principles of Health Management in Aquaculture	17 January–17 April 2021	15	12	Brunei (1) Philippines (11) Singapore (2) Viet Nam (1)
Marine Fish Hatchery	29–14 June 2021	21	5	Brunei (1) Japan (1) Kiribati (5) Papua New Guinea (2) Peru (1) Philippines (8) Singapore (1) Thailand (1) USA (1)
Marine Fish Hatchery	19 July–3 August 2021	13	11	Brunei (1) Cambodia (1) Malaysia (3) Myanmar (1) Philippines (7)
Community-based freshwater aquaculture for remote rural areas of Southeast Asia	16–25 November 2021	12	11	Brunei (1) Malaysia (1) Myanmar (4) Philippines (6)

Due to the COVID-19 pandemic, training courses continued to be offered online. Except for the training on aquatic animal health, online training courses used the Canvas platform and consisted of recorded lecture presentations,

practical video sessions, discussion boards, assignments, downloadable learning materials, live discussion sessions with resource persons, and live group presentations through Zoom.

TRAINING & INFORMATION



With the continuing COVID-19 pandemic, virtual training courses continued to be developed and refined. Publications, information updates, and other materials were also increasingly disseminated through digital means.

Training Program

Since the COVID-19 pandemic is not yet over, SEAFDEC/AQD continued to offer its training courses and on-the-job training for students virtually. Only two in-person courses with limited participants were offered this year. A total of 272 trainees participated in the 17 training

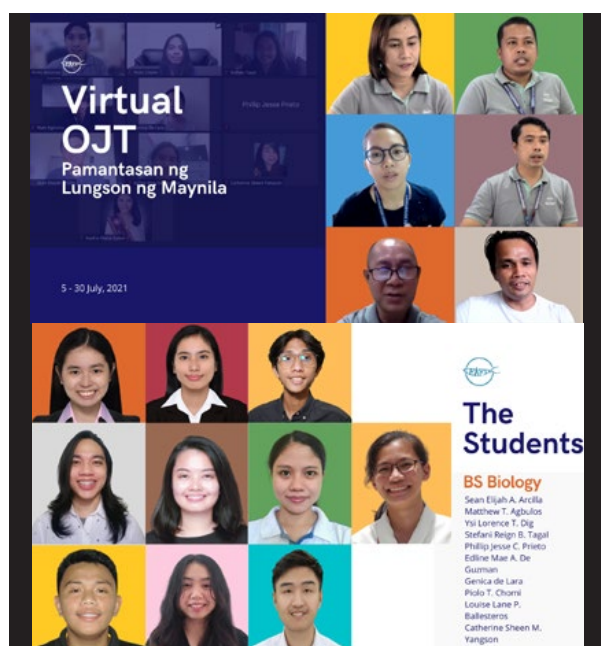
courses offered in 2021, with most participants coming from the private sector (44.9%) followed by Philippine government personnel (32.4%), and the academe (22.8%). Out of the total, 193 or 71 % were from the Philippines, 63 or 23.2 % from other Southeast Asian countries, and

16 or 5.8 % from non-Southeast Asian countries.

SEAFDEC/AQD also conducted online on-the-job training for four different schools and universities in the Philippines with a total of 134 student participants.



Online Training Course on Abalone Nursery & Grow-out for Faculty of Fisheries and Marine Sciences of the Universitas Airlangga in Surabaya, Indonesia



Virtual On-the-Job Training for biology students of the Pamantasan ng Lungsod ng Maynila in Manila, Philippines

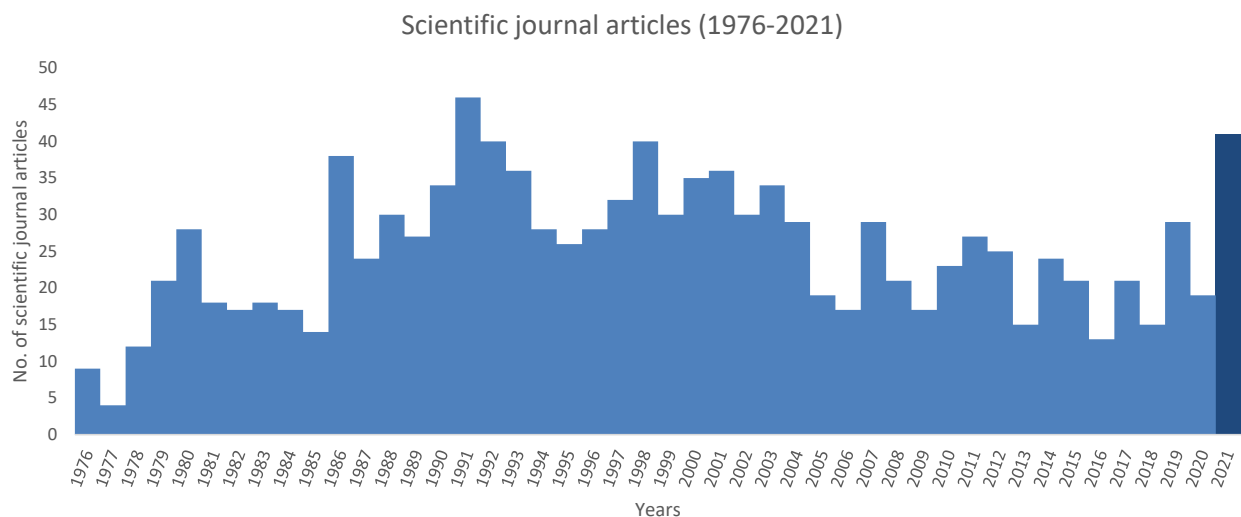
Course, date, venue	Total participants (Male/Female)	Countries represented by participants
Distance Learning Course on Principles of Health Management in Aquaculture 11 January–17 April 2021 (Online)	15 (8 M, 7 F)	Brunei Darussalam, Philippines, Singapore, Viet Nam
Training-Workshop on Basic Video Editing 22–23 March 2021 (TMS, Tigbauan, Iloilo)	17 (9 M, 8 F)	Philippines (SEAFDEC/AQD staff)
Training Course on Shrimp Pond Culture 25–26 March 2021 (Online)	8 (5 M, 3 F)	Philippines

Course, date, venue	Total participants (Male/Female)	Countries represented by participants
Training Course on Freshwater Prawn Hatchery & Grow-out Operations 13–15 April 2021 (Online)	12 (10 M, 2 F)	Philippines
Training Course on Marine Fish Hatchery (Session 1) 14–29 June 2021 (Online)	21 (13 M, 8 F)	Brunei Darussalam, Japan, Kiribati Islands, Papua New Guinea, Peru, Philippines, Singapore, Thailand, USA
Training Course on Aquaculture Technologies for Manpower Development 5 July–5 October 2021 (TMS, Tigbauan, Iloilo)	4 (1 M, 3 F)	Philippines
Training Course on Marine Fish Hatchery (Session 2) 9 July–3 August 2021 (Online)	13 (8 M, 5 F)	Brunei Darussalam, Cambodia, Malaysia, Myanmar, Philippines
Training Course on Bighead Carp Hatchery and Grow-out Operations 21–23 September 2021 (Online)	10 (2 M, 8 F)	Philippines
Training Course on Sandfish (<i>Holothuria scabra</i>) Seed Production, Nursery & Management 6–15 October 2021 (Online)	10 (8 M, 2 F)	Australia, France, Maldives, Malaysia, Pakistan, Philippines, Turkey
Training Course on Mangrove Crab Hatchery Operations 13–20 October 2021 (Online)	23 (14 M, 9 F)	Cambodia, Malaysia, Pakistan, Philippines, Thailand
Training Course on Marine Fish Hatchery (NFRDI) 13–20 October 2021 (Online)	6 (3 M, 3 F)	Philippines
Training Course on Milkfish Culture (NFRDI) 18–28 October 2021 (Online)	5 (2 M, 3 F)	Philippines
Training Course on Abalone Nursery & Grow-out 26–28 October 2021 (Online)	38 (21 M, 17 F)	Indonesia
Training Course on Catfish Hatchery & Grow-out Operations 26–28 October 2021 (Online)	3 (2 M, 1 F)	Philippines
Training Course on Community-Based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia 16–25 November 2021 (Online)	12 (6 M, 6 F)	Brunei Darussalam, Malaysia, Myanmar, Philippines
Training Course on Fish Nutrition & Feed Development 23–26 November 2021 (Online)	67 (34 M, 33 F)	Philippines
Training Course on Mangrove Crab Hatchery Operations (NFRDI) 13–17 December 2021 (Online)	8 (3 M, 5 F)	Philippines

Science Papers in Journals and Proceedings

Articles published in non-SEAFDEC journals and proceedings

1. Altamirano JP, Sinsona MJ*, Caasi OJ*, Uy W*, Noran-Baylon R, Juinio-Meñez MA*. 2021. Factors affecting the spatio-temporal variability in the production of sandfish *Holothuria scabra* juveniles in floating hapa ocean nursery systems. *Aquaculture* 541:736743.
2. Aya FA, Nillasca VSN*, Garcia LMB*. 2021. Improved survival and growth of silver therapon *Leiopotherapon plumbeus* early juveniles through co-feeding with *Artemia* and commercial feeds. *Journal of Applied Ichthyology* 37(6): 925-931.
3. Aya FA, Nillasca VSN*, Garcia LMB*. 2021. Rearing silver therapon *Leiopotherapon plumbeus* (Teleostei: Therapontidae) larvae using euryhaline rotifers as starter food. *Philippine Agricultural Scientist*, 104(4): 388-395.
4. Aya FA, Nillasca VSN, Garcia LMB*. 2021. Effects of weaning on survival and growth of silver therapon (*Leiopotherapon plumbeus*) larvae fed live and artificial diet. *Aquaculture Research* 52:4799-4806.
5. Bagarinao T*. 2021. Biodiversity in mangrove-derived aquaculture ponds in Dumangas, Iloilo, Philippines. *Philippine Journal of Science* 150:153-69.
6. Brakel J*, Sibonga RC*, Dumilag RV*, Montalescot V*, Campbell I*, Cottier-Cook EJ*, Ward G*, Le Masson V*, Liu T*, Msuya FE*, Brodie J*. 2021. Exploring, harnessing and conserving marine genetic resources towards a sustainable seaweed aquaculture. *Plants, People, Planet* 3(4): 337-349. (Review)
7. Cabanilla-Legaspi MI, Traifalgar RF*, de Jesus-Ayson EG*, Andrino-Felarca KG*, Mamauag RE. 2021. Changes in iodide and thyroid hormone levels of hatchery-reared orange-spotted rabbitfish *Siganus guttatus* (Bloch 1787) during early larval development. *Aquaculture Reports* 20:100674.
8. Cabanilla-Legaspi MI, Traifalgar RF*, de Jesus-Ayson EG*, Andrino-Felarca KG*, Mamauag RE. 2021. Growth, metamorphosis and survival of orange-spotted rabbitfish (*Siganus guttatus*) larvae fed sodium iodide-supplemented brine shrimp (*Artemia* sp.). *Aquaculture* 536:736443.
9. Caipang CM*, Deocampo JE*, Pakingking RV, Suharman I*, Fenol JT*, Onayan FB*. 2021. Utilization of sodium bicarbonate as anesthetic during routine husbandry activities in ornamental fish. *IOP Conference Series: Earth*



and Environmental Science 934(1): 012001.

10. Caipang MA*, Deocampo JE*, Fenol JT*, Onayan F*, Yerro EBS*, Caipang CLMA*, Pakingking RV Jr. 2021. Utilization of a portable glucometer for the measurement of tissue glucose as a stress indicator in ornamental fish. *Poeciliid Research*, 11(1): 30-35.
11. Deocampo JE*, Fenol JT*, Yerro EBS*, Pakingking RV Jr., Caipang MA*. 2021. Biofloc technology (BFT): A promising approach for the intensive production of ornamental fish. *Poeciliid Research*, 11(1): 18-24.
12. Espino M, Eguiraun H*, Diaz de Cerio O*, Carrero JA*, Etxebarria N*, Martinez I*. 2021. Antioxidant activities and selenogene transcription in the European sea bass (*Dicentrarchus labrax*) liver depend, in a non-linear manner, on the Se/Hg molar ratio of the feeds. *Biological Trace Element Research* 200(5):2365-2379.
13. Estante-Superio EG, Santander-Avanceña SS, de la Peña LD, Garibay ES, Gardoche RS*, Dayrit R. 2022. Growth performance, production and economic viability of Indian white shrimp (*Penaeus indicus* H. Milne Edwards) fed with varying dietary protein levels. *Aquaculture Research* 53(4): 1563-1572.
14. Estrullo-Suaga E*, Miaque-Crucero MJ*, Superio DL. 2021. Undervalued, understaffed, underdeveloped, and underutilized? The status of public libraries in the eleven municipalities of rural Iloilo Province, Philippines. *Information Development* (first published online)
15. Faisan JP, Luhan MR*, Sibonga RC*, Mateo JP*, Ferriols VM*, Brakel J*, Ward GM*, Ross S*, Bass D*, Stentiford GD*, Brodie J*. 2021. Preliminary survey of pests and diseases of eucheumatoid seaweed farms in the Philippines. *Journal of Applied Phycology* 33: 2391–2405.
16. Ito S, Tamura Y*, Sato A*, Onishi H*, Shibuya M*, Uchida Y*, Inoue M*, Omori K*. 2022. Occurrence and disappearance of a non-native goby *Rhinogobius* sp. OR in relation to hydrological conditions in the Kamo River, southwestern Japan. *Ichthyological Research*
17. Kodama M*, Diamante RA, Salayo ND, Castel RJ, Sumbing JG*. 2021. Growth performance and condition factor of juvenile milkfish (*Chanos chanos*) cultured in a marine pen in relation to body size and temperature. *Japan Agricultural Research Quarterly* 55:191-200.
18. Kuroda H*, Tanaka T*, Ito S, Setou T*. 2021. Numerical study of diurnal tidal currents on the Pacific shelf off the southern coast of Hokkaido, Japan. *Continental Shelf Research* 230:104568.
19. Leбата-Ramos MJ, Biñas JB, Solis EF, Balinas VT*. 2021. Flakes versus noodles as feed for the abalone *Haliotis asinina*, does form matter?. *Aquaculture Nutrition* 27(6): 1880-1887.
20. Leбата-Ramos MJ, Dionela CS*, Novilla SR*, Sibonga RC*, Solis EF, Mediavilla JP*. 2021. Producing young, single and meaty oyster *Crassostrea iredalei* (Faustino, 1932) in grow-out culture using pouches suspended from rafts. *Aquaculture Research* 69: 176–181.
21. Leбата-Ramos MJ, Mediavilla JP*, Solis EF, Sibonga RC*, Alicante FP*, Dionela CS*. 2021. Nursery and grow-out culture of the abalone *Haliotis asinina* on a reef flat: a comparison of growth and survival using different culture containers. *Aquaculture* 541:736786.
22. Leбата-Ramos MJ, Solis EF. 2021. Can *Ulva reticulata* replace *Gracilariopsis heteroclada* as natural food for the abalone *Haliotis asinina*? *Journal of Applied Phycology* 33:1869-1872.
23. Ludevese-Pascual G*, Laranja JI*, Ahmed F*, Amar E, De Troch M*, Bossier P*, De Schryver P*. 2021. Lipids and fatty acid composition in the crustacean model organism *Artemia* sp. as influenced by poly-β-hydroxybutyrate (PHB) supplementation. *Aquaculture Nutrition* 26:2235-2244.
24. Mamauag RE, Ragaza JA*, Nacionales TJ. 2021. Performance, digestibility efficiencies, gut and liver morphologies of snub nose

This list is compiled based on the 2021 author reports to the SEAFDEC/AQD Databank. Publications dated 2022 were electronically available in 2021 and published in a journal issue in 2022. Askterisks (*) indicate non-SEAFDEC authors or SEAFDEC personnel who have retired or separated from service prior to the publication date.

- pompano *Trachinotus blochii* fed spray-dried haemoglobin meal as protein substitute for fishmeal. *Aquaculture Research* 52(1): 5849-5856.
25. Mamauag REP, Catacutan MR, Coloso RM*, Erazo-Pagador G, Mallare M, Ragaza JA*. 2021. Dietary taurine in practical diet for two sizes of snubnose silver pompano, *Trachinotus blochii*. *Aquaculture Nutrition* 27(6): 2231-2239.
 26. Mandal A*, Mani AK*, Lamech R*, Anandajothi E*, Venkatachalam SA*, Dinakaran GK*, Quinitio ET*, Kandan S*. 2021. Genetic identification of all four mangrove mud crab species (genus *Scylla*) using multiple molecular markers. *Biochemical Genetics* 59: 856–869.
 27. Mandario MAE, Castor NJT, Balinas VT*. 2022. Effects of feeding rate and sediment depth on the survival, growth performance, and biomass of mud polychaete *Marphysa iloiloensis* from early juvenile to adult in grow-out tanks. *Aquaculture* 548:737731
 28. Mangano MC*, Berlino M*, Corbari L*, Milisenda G*, Lucchese M*, Terzo S*, Bosch-Belmar M*, Azaza MS*, Babarro JMF*, Bakiu R*, Broitman BR*, Buschmann AH*, Christofolletti R*, Dong Y*, Glamuzina B*, Luthman O*, Makridis P*, Nogueira AJA*, Palomo MG*, Dineshram R*, Sanchez-Jerez P*, Sevgili H*, Troell M*, AbouelFadl KY*, Azra MN*, Britz P*, Carrington E*, Celić I*, Choi F*, Qin C*, Dionísio MA*, Dobroslavić T*, Galli P*, Giannetto D*, Grabowski JH*, Helmuth B*, Leбата-Ramos MJH, Lim PT*, Liu Y*, Llorens SM*, Mirto S*, Pećarević M*, Pita C*, Ragg N*, Ravagnan E*, Saidi D*, Schultz K*, Shaltout M*, Tan SH*, Thiyagarajan V*, Sarà G*. 2022. The aquaculture supply chain in the time of covid-19 pandemic: Vulnerability, resilience, solutions and priorities at the global scale. *Environmental Science & Policy* 127:98–110.
 29. Marini M*, Pedrosa-Gerasmio IR*, Santos MD*, Shibuno T*, Daryani A*, Romana-Eguia MR, Wibowo A*. 2021. Genetic diversity, population structure and demographic history of the tropical eel *Anguilla bicolor pacifica* in Southeast Asia using mitochondrial DNA control region sequences. *Global Ecology and Conservation* 26:e01493.
 30. Mateo JP*, Campbell I*, Cottier-Cook EJ*, Luhan MR*, Ferriols VM*, Hurtado AQ*. 2021. Understanding biosecurity: knowledge, attitudes and practices of seaweed farmers in the Philippines. *Journal of Applied Phycology* (online first)
 31. Oducado RMF*, Tuppal CP*, Estoque HV*, Sadang JM*, Superio DL, Real DVC*, Roa MNT*, Malaga XG*, Quiros JD*, Fajardo MTR*, Dela Rosa RD*. 2021. Uso de Internet y la alfabetización en eSaludcon temor al COVID-19 entre estudiantes de enfermería en Filipinas [Internet use, eHealth literacy and fear of COVID-19 among nursing students in the Philippines]. *International Journal of Educational Research and Innovation (IJERI)* 15:487-502.
 32. Pakingking Jr R, Hualde M*, Peralta E*, Faisan J, Usero R*. 2022. Microbiological quality and levels of heavy metals in slipper oyster (*Crassostrea iredalei*) cultured in major growing areas in Capiz province, Western Visayas, Philippines: Compliance with international shellfish safety and sanitation standards. *Journal of Food Protection*. 85(1):13-21. (Research Note)
 33. Romana-Eguia MRR, Rutaquio MP, Gutierrez RC, Salayo ND. 2021. Assessment of tilapia–freshwater prawn co-culture schemes in tanks and lake-based cages for increased farm production. *Sustainability* 13:13574.
 34. Sarà G*, Mangano MC*, Berlino M*, Corbari L*, Lucchese M*, Milisenda G*, Terzo S*, Azaza MS*, Babarro JM*, Bakiu R*, Broitman BR*, Buschmann AH*, Christofolletti R*, Deidun A*, Dong Y*, Galdies J*, Glamuzina B*, Luthman O*, Makridis P*, Nogueira AJA*, Palomo MG*, Dineshram R*, Rilov G*, Sanchez-Jerez P*, Sevgili H*, Troell M*, AbouelFadl KY*, Azra MN*, Britz P*, Brugere C*, Carrington E*, Celić I*, Choi F*, Qin C*, Dobroslavić T*, Galli P*, Giannetto D*, Grabowski J*, Leбата-Ramos MJH, Lim PT*, Liu Y*, Llorens SM*, Maricchiolo G*, Mirto S*, Pećarević M*, Ragg N*, Ravagnan E*, Saidi D*, Schultz K*, Shaltout M*, Solidoro C*, Tan SH*, Thiyagarajan V*, Helmuth B*. 2021. The synergistic impacts of anthropogenic stressors and COVID-19 on aquaculture: A current global perspective. *Reviews in Fisheries Science & Aquaculture* 19:1-3. (note)

35. Shrestha A*, Lilagan CAI*, Guiao JEB*, Romana-Eguia MRR, Lagman A*, Carmen M*. 2021. Comparative transcriptome profiling of heat stress response of the mangrove crab *Scylla serrata* across sites of varying climate profiles. *BMC Genomics* 22:580.
36. Sibonga RC*, Laureta LV*, Leбата-Ramos MJ, Nievales MF*, Pedrosa FL*. 2021. Single and mixed species of microalgae as larval food for the tropical sea cucumber *Holothuria scabra*. *Journal of Applied Phycology* 33: 3103–3112.
37. Superio DL, Anderson KL*, Oducado RMF*, Luceño MT*, Palloculo VEV*, Bendalian MVT*. 2021. The information-seeking behavior and levels of knowledge, precaution, and fear of college students in Iloilo, Philippines amidst the COVID-19 pandemic. *International Journal of Disaster Risk Reduction* 62:102414.
38. Suyo JG*, Le Masson V*, Shaxson L*, Luhan MR*, Hurtado AQ*. 2021. Navigating risks and uncertainties: Risk perceptions and risk management strategies in the Philippine seaweed industry. *Marine Policy* 126:104408.
39. Vicary T*, Kalentsits M*, Superio D, Keita A*. 2021. Increasing the availability of West African Grey Literature to improve marine fisheries management. In: Farace D, Frantzen J (compilers). *Conference Proceedings: Twenty-Second International Conference on Grey Literature*. National Research Council of Italy; November 19, 2020; National Research Council of Italy: pp. 18-24. (textrelease).
40. Villa-Franco AU, de la Peña MR, Igcasan Jr HP, Gamuza GB, Teves CM, Balinas VT*. 2021. Production, feeding and storage of diatom *Chaetoceros calcitrans* paste by electrolytic flocculation with reduced Pb content. *Aquaculture Research* 52(7): 3148-3156.
41. Ward GM*, Kambey CS*, Faisan JP Jr, Tan PL*, Daumich CC*, Matoju I*, Stentiford GD*, Bass D*, Lim PE*, Brodie J*, Poong SW*. 2022. Ice-Ice disease: An environmentally and microbiologically driven syndrome in tropical seaweed aquaculture. *Reviews in Aquaculture* 14: 414-439. (Review)

Other Publications

Once technologies are verified, SEAFDEC/AQD packages its research findings and other developments in aquaculture to other publications that cater to a broad scope of stakeholders including governments, the academe, extension workers, fish farmers, and the general public.

This year, a Filipino-language extension manual, *Mga Teknolohiya sa Pagpapanaak ng mga Isdang Tabang (Technologies on the Breeding of Freshwater Fish)*, was published and disseminated through the SEAFDEC/AQD institutional repository.

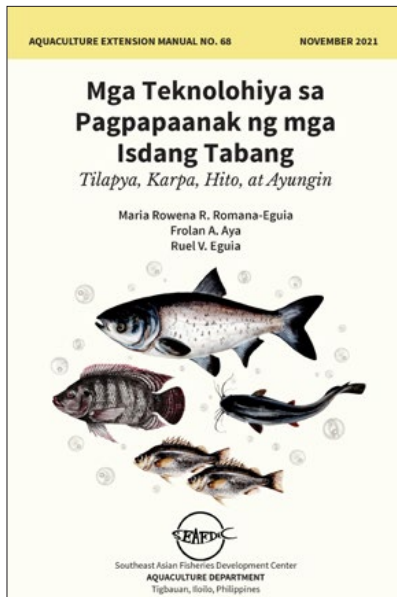
Also published was *Promotion of Sustainable Aquaculture, Aquatic Animal Health, and Resource Enhancement in Southeast Asia* which is the proceedings of the International Workshop on the Promotion of Sustainable Aquaculture, Aquatic Animal Health, and Resource Enhancement in Southeast Asia that was held in 2019.

Six issues of the bimonthly newsletter *AQD Matters* was published this year. A brochure on *Feed Mill Products and Services* was also produced. The annual report *SEAFDEC/AQD Highlights 2020* was released, and a primer on *SEAFDEC/*

AQD Priority Infrastructure was made.

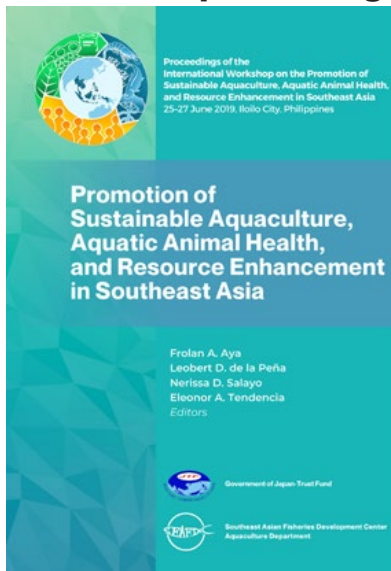
To accelerate information dissemination, 21 publications from previous years were released for open access by the public through the SEAFDEC/AQD Institutional Repository. These include aquaculture extension manuals, a nutrition textbook, and a mangrove field guide, among others. The initiative was promoted as “Accessible, Quality, Detailed Scientific Information for All” and publications were promoted individually on social media with the #AQDFreeAccessFridays hashtag.

Extension manual



Mga Teknolohiya sa Pagpapaanak ng mga Isdang Tabang (Aquaculture Extension Manual No. 68)

Conference proceedings



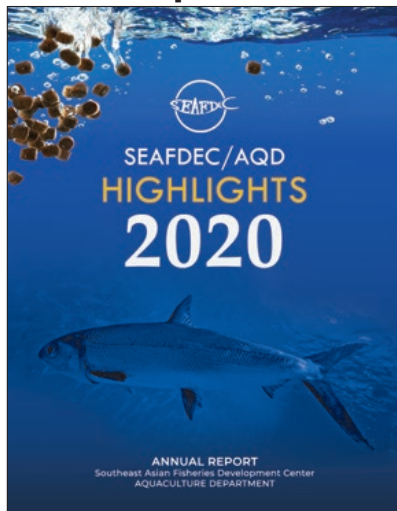
Promotion of Sustainable Aquaculture, Aquatic Animal Health, and Resource Enhancement in Southeast Asia

Newsletter



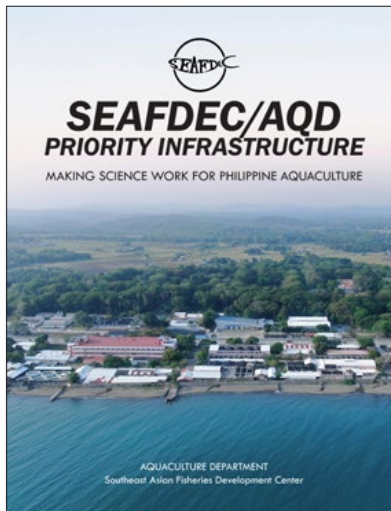
Six issues of the AQD Matters newsletter released bimonthly in 2021

Annual Report



SEAFDEC/AQD Highlights 2020 Annual Report

Primer



Primer on SEAFDEC/AQD Priority Infrastructure

Brochure



Feed Mill Products and Services

Online Platforms

The online channels of SEAFDEC/AQD provided the latest news through the official website (www.seafdec.org.ph) and Facebook page (fb.com/seafdec.aqd). Meanwhile, the SEAFDEC/AQD Institutional Repository (repository.seafdec.org.ph) continues to make publications authored by SEAFDEC/AQD specialists available to the public, with PDF copies mainly accessed through search engines.

While information on the website continued to be improved and updated, users declined by 1.74% to 49,129 compared to the same period in 2020.

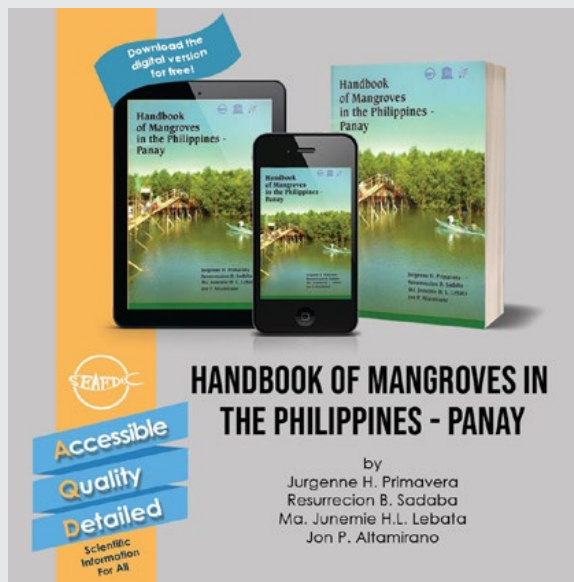
The official Facebook page was the more active platform with a total of 185 posts made in 2021. More infographics were produced to improve content quality. Followers continued to increase significantly, this year by 48.3% to 20,044, compared to the same period last year.

Usage of the SEAFDEC/AQD Institutional Repository continued to grow with total downloads reaching 388,773, an 8.5% increase from 2020. During this time, 248 new items were archived bringing total downloadable items to 1987.

Messages and queries from all over the world are received by SEAFDEC/AQD through its website and social media. In 2021, messages received through the website and Facebook totaled 1,786. Most of the messages were on hatchery seedstocks (33.9%) and training and internship (22.2%). Messages are relayed to concerned offices within SEAFDEC/AQD where they are accommodated.

A virtual aquaculture outreach was piloted in July 2021 with ten on-the-job trainees (OJTs) tasked

Virtual library boosts access to aquaculture publications amid COVID-19



Social media promotion of the highly-requested *Handbook of Mangroves in the Philippines-Panay* which led to thousands of downloads of the publication

Libraries might have been closed due to the COVID-19 pandemic, but those with internet access would still have had access to thousands of publications on aquaculture and fisheries technologies. SEAFDEC/AQD has given the public unrestricted access to over 1,800 publications, including full-text digitized books, extension manuals, conference proceedings, annual reports, and other materials authored by the organization's scientists and researchers.

The publications are available online through the SEAFDEC/AQD Institutional Repository (SAIR) although users may already be unknowingly accessing the PDF files through search engine results.

The need for openly accessible digital publications was highlighted by the shift to online learning and alternative working arrangements brought about by the onset of the COVID-19 pandemic beginning 2020.

In 2021, SEAFDEC/AQD launched Free Access Fridays through the Facebook platform, recently, where a curated collection of the organization's best open access titles is promoted including farmer-oriented manuals on the farming of tilapia, shrimp, seaweed, catfish, and big-head carp.

Some titles have been long out of print, including the much-requested *Handbook of Mangroves in the Philippines – Panay* authored by Dr. Jurgenne Primavera, a native tree advocate and scientist emerita of SEAFDEC/AQD, along with Dr. Rex Sadaba, Dr. Junemie Lebata-Ramos, and Dr. Jon Altamirano. Dr. Primavera thanked SEAFDEC/AQD for making a digital copy available online which, she says, saves readers from the US\$100 cost currently being charged by foreign book resellers for original prints.

to answer aquafarmer inquiries on various fish farmer Facebook groups. The OJTs comprehensively responded to 320 different inquiries in Filipino and provided links to SEAFDEC/AQD information materials and other trustworthy sources.

News and Media

SEAFDEC/AQD continued to produce press releases to facilitate dissemination of information through the mass media and accelerate the growth of its reach to stakeholders. Twenty press releases were produced in 2021 which contributed to 38 appearances in newspapers and magazines and 45 appearances on websites of recognized press outlets. Of these, at least 10 appearances were on international magazines or websites.

WEBSITE



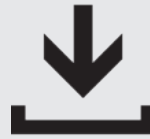
49K

(-0.9K ▼ 1.7%)

2021 UNIQUE USERS

Most users come from the Philippines (54%), China (14%), and the U.S. (9%)

REPOSITORY



389K*

(+30.3K ▲ 8.5%)

2021 DOWNLOADS

*Reported statistic excludes downloads by bots and crawlers

FACEBOOK



31K

(+7.3K ▲ 30.4%)

FACEBOOK FOLLOWERS

Combined likes of Facebook pages (including Library, FishWorld)

YOUTUBE



43K

(-18.6K ▼ 30.0%)

2021 YOUTUBE VIEWS

Views mostly from instructional videos of aquaculture commodities



SEAFDEC/AQD press releases resulted in dozens of articles in newspapers and magazines

Info squad infiltrates online farmer groups, battles misinformation, delivers quality answers

Fish farmer groups on Facebook had become a haven during the COVID-19 lockdowns for those seeking for help and answers as they troubleshoot their day-to-day activities. However, with discussions being open to the public, the platform is also prone to misinformation especially when clear and understandable information from authoritative sources is absent or inaccessible.

To battle the lack of information, as well as misinformation, SEAFDEC/AQD unleashed 10 of its on-the-job trainees (OJTs) to scour for questions within fish farmer communities on Facebook and research for answers using SEAFDEC/AQD's vast repository of digitized publications.

The OJTs, all biology majors of the Pamantasan ng Lungsod ng Maynila (University of the City of Manila) also known as PLM, focused on Philippine farmer groups such as "Tilapia Farming Philippines" which during that time had 43,800 members, "Freshwater Fish Farming in the Philippines" (38,600 members), "Freshwater prawn {ulang} philippines" (8,200 members), and "Tilapia and Hito Farming" (8,000 members).

Between 5 and 29 July 2021, the OJTs-cum-keyboard-warriors provided at least 320 farmers with answers complete with links to reliable references and downloads from SEAFDEC/AQD, the Food and Agriculture Organization (FAO), the Bureau of Fisheries and Aquatic Resources (BFAR), and others.

The comprehensive answers provided by the OJTs were provided in Filipino language and were well received by the readers.

Genica de Lara
Magandang araw po!

Ang dami ng tilapia kada square meter ay nakadepende sa kung papaanong pakain ang gagawin nyo. Kapag po extensive system kung saan gagamit kayo ng natural na pagkain sa pamamagitan ng paglalagay ng fertilizer, maaari kayong maglagay ng 1-2 tilapia fingerlings/m². Kapag naman semi-intensive kung saan kumakain sila ng natural na pagkain at binibigyan nyo rin ng supplemental feed, maaari kayong maglagay ng 3-4 tilapia fingerlings/m². Kailangan pa rin ang tamang paghahanda ng pond at paglalagay ng fertilizer. Kapag naman intensive o purong feed ang kinakain ng inyong tilapia, pwede kayong maglagay ng 5-10 tilapia fingerlings/m². Dito mas mataas dapat ang pag maintain ng quality ng tubig dahil mas mataas ang stocking density kumpara sa mga nauna.

So, kung meron kayong 500 m²:
 *extensive: 500-1000 fingerlings
 *semi-intensive: 1500-2000 fingerlings
 *intensive: 2500-5000 fingerlings

Para sa maraming kaalaman pa tungkol sa pag-aalaga ng tilapia maaaring gamitin ang mga links na ito:
<https://repository.seafdec.org.ph/handle/10862/2401>
<https://repository.seafdec.org.ph/.../5842-Romana...?>

REPOSITORY.SEAFDEC.ORG.PH
Tilapia farming in cages and ponds

Like · Reply · Share · 12w

Genica de Lara yeah Good ito Galing Mismo SEAFDEC ng Iloilo.
Like · Reply · Share · 12w

Just one of over 300 answers posted by on-the-job trainees at SEAFDEC/AQD in response to questions in fish farmer groups on Facebook.

Advantages ng Concrete Pond:

1. Mas madaling bantayan at makita kung ano ang nangyayari sa mga tilapia. Importanteng makita ang kanilang behavior upang masuri kung sila ay healthy o may sakit.
2. Mas madaling bilangin at iharvest ang mga tilapia.
3. Madali din mabantayan kung gaano kalakas sila kumain.
4. Kontrolado kung ano ang kanilang kakainin kaya maaaring makaiwas sa lasang giilik na dulot ng pagkain sa mga algae.

Para sa karagdagang impormasyon ukol sa Tilapia Pond Setup, lalo na sa mga advantages ng Earthen at Concrete pond, maaaring bisitahin ang mga sumusunod na link:
<https://repository.seafdec.org.ph/.../5842-Romana...>
<https://agric4profits.com/find-out-earthen-pond-vs-.../>
<https://www.agrifarming.in/how-to-build-a-fish-pond-with...>

Maraming salamat po! Sana ay makatulong.

Like · Share · 10w

Matt Tua Agbulos thank u po sa information nato, God bless
Like · Share · 10w · Edited

Matt Tua Agbulos yan ang taong may malasakit sa kapwa na gusto ding mag alaga ng tilapia..para pareparehong mabuhay at magkaroon ng kabuhayan..napakalinaw magbigay ng kaalaman ...d madamot na ishare ang kaalaman.. SIR SALUDO PO AKO SAYO..D BEST KA... GOD BLESS PO..MORE POWER 🙏🙏🙏🙏
Like · Share · 9w

Matt Tua Agbulos
Salamat po sir
Like · Share · 9w

Cropped screenshot of the answer an on-the-job trainee provided, and reactions from readers, all happening within a Facebook group of fish farmers

FishWorld

FishWorld is SEAFDEC/AQD's visitor center and museum of aquatic biodiversity. Since the beginning of COVID-19 pandemic, the museum closed its doors to visitors. However, the works on conservation of endangered megafauna was not hindered.

In 2021, FishWorld was able to release a total of 117 turtle hatchlings from 3 different municipalities in Iloilo. It also assisted in the release of three sea turtles (1 olive ridley, 2 hawksbill) at the Igang Marine Station in collaboration with the Provincial Environmental Office of Guimaras, and one olive ridley in Tigbauan, Iloilo. FishWorld also assisted the National Museum of the Philippines – Western Visayas in the dissection of a dead sunfish found in Oton, Iloilo.

FishWorld opened its doors to visitors on December 2021 with health protocols in place to keep the visitors and FishWorld staff safe from COVID-19.



FishWorld staff assisting the National Museum of the Philippines – Western Visayas in the dissection of a dead sunfish at Oton, Iloilo



Technical staff and volunteers from FishWorld of SEAFDEC/AQD facilitated the release of 17 olive ridley turtle hatchlings in Tigbauan, Iloilo on March 2021



PRODUCTION & SERVICES

Seedstock production continued to be ramped up to help support the local aquaculture sector. Market-size commodities were also produced as byproducts of research and verification activities. Service laboratories provided for the research needs of SEAFDEC/AQD as well as the private sector, academe, and government.

Hatchery and grow-out production

To help address the shortage of aquaculture seeds in the Philippines, the host country of SEAFDEC/AQD, two multi-species hatcheries and a milkfish broodstock facility were built at the institution's main station in Tigbauan, Iloilo. These new facilities began operating in 2021 that contributed to the increase in fry production.

This growth in production is notable in this year's milkfish fry production wherein 13.7 million fry were produced and harvested that is about five million higher than the milkfish fry production in 2020. Aside from the establishment of new facilities, other factors such as the acquisition of new milkfish breeders and the environmental manipulation through water heaters applied in broodstock tanks that induced the gonadal maturation and spawning of milkfish breeders even during the cold season, also played important roles in the increase in production.

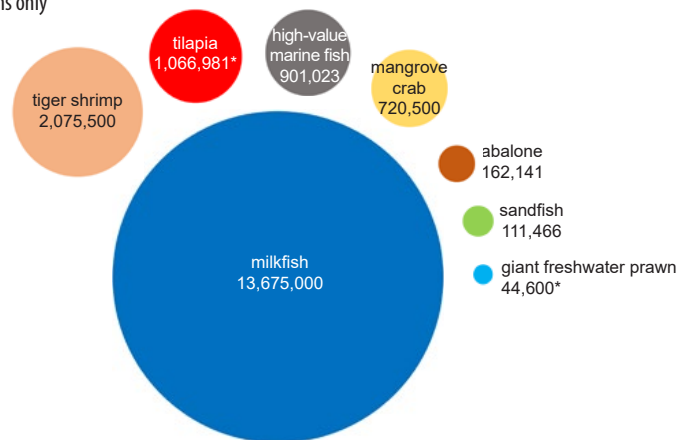
Moreover, tilapia fry production increased by about three hundred thousand in 2021 compared to the 747,953 fry harvested in 2020. The rise in production is mainly due to the reduced level of travel restrictions brought about by the COVID-19 pandemic, which made SEAFDEC/AQD-produced tilapia fry more accessible to tilapia farmers from nearby provinces. In addition, the Department was able to cope with the demand because of the new hatchery facilities that provided additional breeders and larval rearing tanks for the tilapia fry production.

Lastly, with these new aquaculture facilities, SEAFDEC/AQD's main station in Tigbauan, Iloilo started producing giant freshwater

Seedstock produced and harvested in 2021

pieces of fry for fish, postlarvae for shrimp and prawn, early juveniles for abalone and sandfish, crab instar 1 for mangrove crab

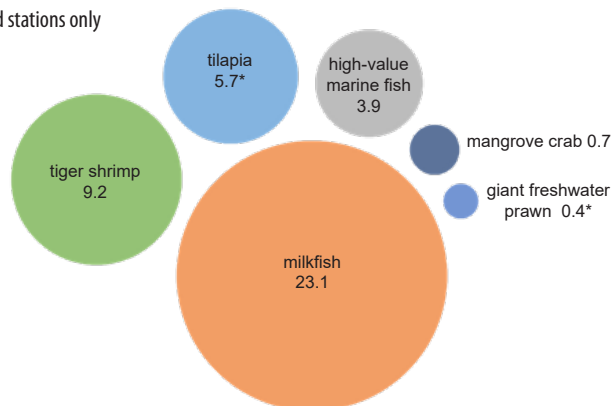
*Iloilo-based stations only



Market-size commodities harvested in 2021

in metric tons

*Iloilo-based stations only



prawn postlarvae with a total of 44,600.

For the production of market-sized commodities, a marked increase in the total harvest of milkfish, tiger shrimp, and tilapia were observed. The spike in production is due to research and production trials done by SEAFDEC/AQD on the grow-out culture of these species.

Milkfish grow-out production this year increased by about 8.5 tons compared to the 14.6 tons total harvest in 2020. On the other hand, total harvest of market-sized tilapia increased more than a tripled from 1.5 tons to 5.7 tons. Tiger shrimp harvest also increased from 5.6 tons in 2020 to 9.1 tons this year.

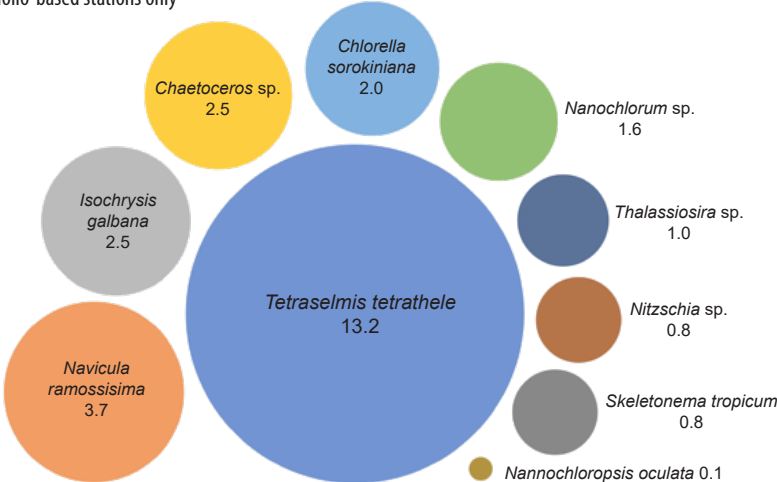
Larval food production

To support the research and production activities of SEAFDEC/AQD, the larval food laboratory produced 28,200 liters (liquid) and 43.42 kilogram (paste) of microalgal and rotifer starters. Bulk of the liquid microalgal starters produced, around 26,800 liters, was used for SEAFDEC/AQD's research projects and the rest was sold to the institution's clients.

The demand from SEAFDEC/AQD studies resulted to the four-fold increase in production of liquid microalgal starters compared to last year's production. In addition, more microalgal species were cultured this year based on the larval food requirement of the aquaculture seed production studies conducted.

Types of liquid starters produced in 2021

in thousands of liters
Iloilo-based stations only



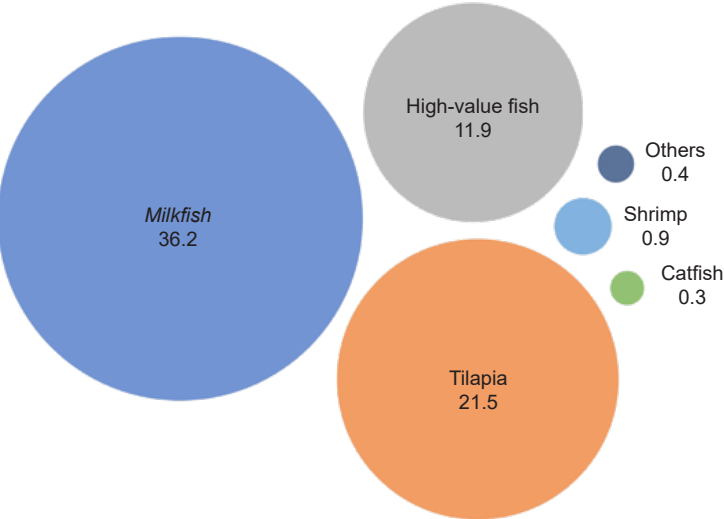
Feed mill production

In 2021, the Feed Mill produced more than 75 tons of aquafeeds and ingredients for various commodities that increased by about 42% from last year's production. Specifically, the increase is mainly due to SEAFDEC/AQD's grow-out study on tilapia co-cultured with giant freshwater prawn, which resulted to the spike in the production of tilapia feed from 4.6 tons in 2020 to more than 21 tons in 2021.

A total of about 6.7 tons were produced by Feed Mill for external clients from the private sector and the academe wherein six tons of which is milkfish diet ordered by the private sector..

Total aquafeed production in 2021

in metric tons

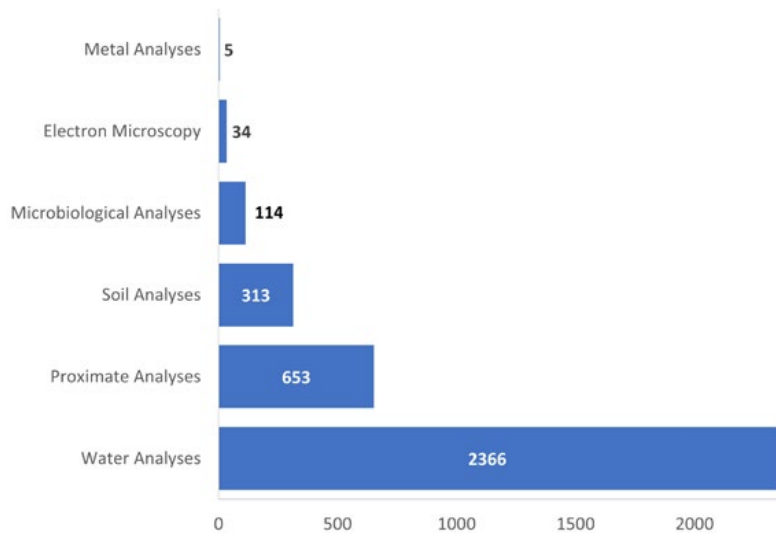


Analytical Services

The Centralized Analytical Laboratory (CAL) under the Laboratory Facilities for Advanced Aquaculture Technologies (LFAAT) was granted an ISO/IEC 17025:2017 accreditation for its biological and chemical testing by the Philippine Accreditation Bureau this year. Accredited laboratory services include water analyses such as total coliform count, fecal coliform count, pH level, ammonia-nitrogen, nitrite-nitrogen, and phosphate-phosphorus. Also included in the accreditation is the chemical testing of agricultural products and materials for moisture, ash, and crude protein analyses.

LFAAT accepted 1,068 samples in 2021, most of which were analyzed in support of SEAFDEC/AQD's various research programs. Other samples were submitted by

Types of analyses conducted



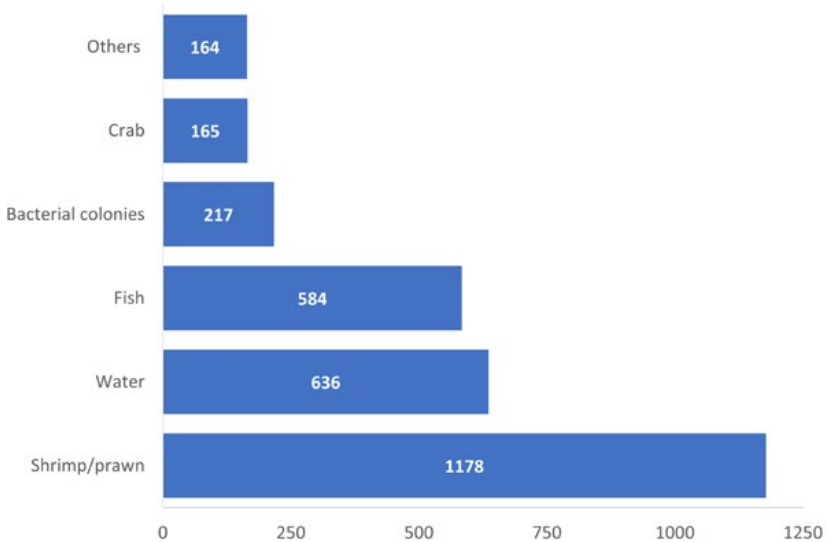
stakeholders from the private sector, the academe, and government agencies. Of these samples, a total of 3,485 determinations were

conducted by the laboratory. LFAAT also received 15 requests on the use of laboratory facilities.

Diagnostic Services

The Fish Health Section handles diagnostic cases for a range of viruses, bacteria and parasites. Diagnostic services catered to 2,944 cases in 2021, mostly provided with shrimp samples. Diseases were detected mainly through polymerase chain reaction (PCR) with 1,896 samples analyzed. Acute hepatopancreatic necrosis disease (AHPND) was the most requested disease for diagnosis with 699 samples analyzed followed by white spot syndrome with 577 samples. Bacterial count was also done on 1,014 samples and bacterial identification was done for 191 samples with the same number of isolates. Meanwhile, the Microtechnique Laboratory released 852 slides from 755 samples received.

Types of diagnostic cases examined



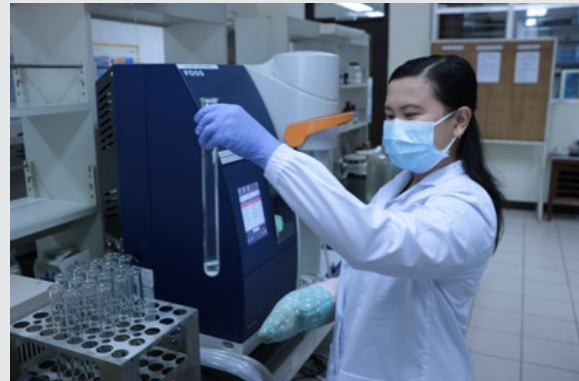
SEAFDEC/AQD lab now ISO-accredited

World-class quality testing can now be enjoyed by fish farmers and researchers for their feeds and water samples at the Centralized Analytical Laboratory (CAL) of SEAFDEC/AQD in Tigbauan, Iloilo, Philippines.

The Philippine Accreditation Bureau (PAB) granted the ISO/IEC 17025:2017 accreditation for the biological and chemical testing of the laboratory on 21 Oct. 2021, which means that the facility meets internationally accepted standards in its analytical procedures and has an effective laboratory quality management system.

Accredited laboratory services include water analyses such as total coliform count, fecal coliform count, pH level, ammonia-nitrogen, nitrite-nitrogen, and phosphate-phosphorus. Also included in the accreditation is the chemical testing of agricultural products and materials for moisture, ash, and crude protein analyses.

CAL, which analyzed almost 2,000 samples in 2020, caters mainly to AQD's own researchers, but also accepts samples from the public.

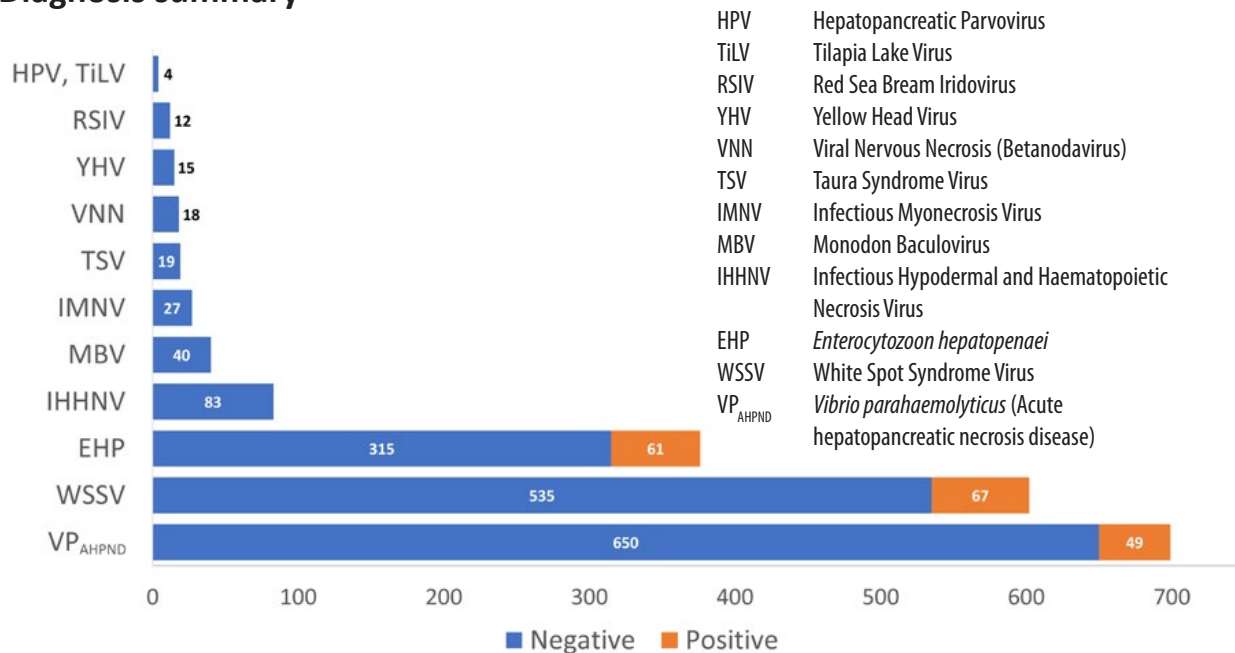


Sample processing for crude protein analysis

ISO/IEC 17025:2017 is the most recent version of ISO standard for testing and calibration laboratories. This specifies the general requirements for the competence, impartiality, and consistent operation of testing and calibration laboratories.

The accreditation also shows that the laboratory has the technical competence and provides reliable, accurate, and defensible test results with the highest attainable standard of quality recognized internationally.

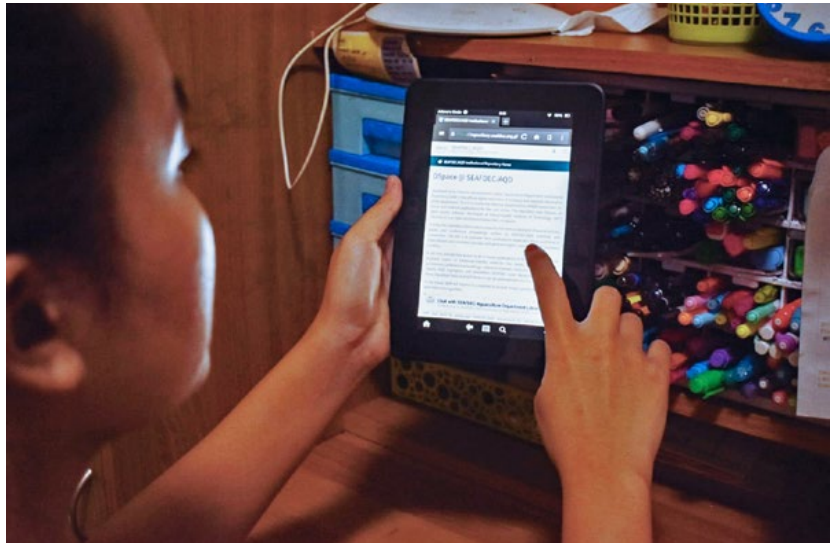
Diagnosis summary



Library services

The present collection of the SEAFDEC/AQD Library stands at 47,010 titles with 81,579 volumes or copies. The collections stand at 21,574 monographs, 5,880 SEAFDEC publications, 20,727 bound serial volumes, 10,762 pamphlets, and a variety of maps, posters, microfiche, and CD-ROMs. These were available for use and could be searched online through the SEAFDEC/AQD Library Online Public Access Catalog (OPAC). OPAC was visited by a total of 2,658 global searchers. In addition, the library offers access to the following databases: Aquatic Sciences and Fisheries Abstracts (ASFA), ProQuest Central, and The Essential Electronic Agricultural Library (TEEAL).

A total of 2,987 (1,967 SAIR; 1,020 in-house) document requests were received from about 1,533 (1,458 SAIR; 75 in-house) individ-



A student accesses the SEAFDEC/AQD Institutional Repository using a mobile device.

uals. Sixty-six percent of the documents requested were placed through the SEAFDEC/AQD Institutional Repository (SAIR). The majority of the requesters were from the Philippines, India, Malaysia, Indonesia, USA, Singapore, Thailand, United Kingdom, Sri Lanka, Denmark, Ger-

many, Uganda, etc. The remaining percentage of documents requested were in person and remotely, through email, phone, chat, and Facebook messenger, the majority by SEAFDEC/AQD employees.

HUMAN RESOURCES AND FINANCE

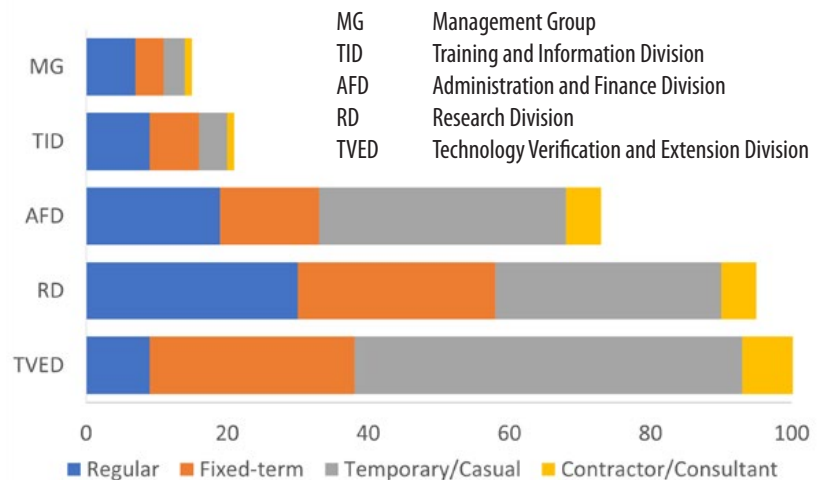


The SEAFDEC/AQD workforce remained resilient and adaptable in the face of COVID-19. New research and production facilities continued to be constructed, backed by robust financial support from donors.

Personnel distribution

As of end of 2021, SEAFDEC/AQD's personnel numbered 305 composed of 74 regular employees, 82 fixed-term staff, 129 casuals, and 20 contractors/consultants. The Technology Verification and Extension Division (TVED) had the most staff (101) assigned to it, followed by the Research Division (RD) with 95, Administration and Finance Division (AFD) with 73, and the Training and Information Division (TID) with 21. The Management Group was composed of 15 personnel.

Personnel distribution across divisions



Daryl Superio receives 2021 ASLP Professional Award

For his significant contributions and achievements in special librarianship, Mr. Daryl Superio, officer-in-charge of the SEAFDEC/AQD Library and Databanking Services Section, received the Professional Award last 28 Jan. 2021.

The award was conferred by the Association of Special Libraries of the Philippines (ASLP), a non-profit organization composed of special librarians from various sectors, during the association's 68th General Assembly via Zoom.

The ceremony highlighted how Mr. Superio's exemplary performance on library research and publishing together with this service and dedication to the cause of various national and international special library associations contributed to the advancement of the field.



Photo courtesy of the ASLP Facebook Page

"This recognition inspires me to contribute more to special librarianship in the Philippines, not just through the number of publications but also through initiatives that will benefit librarianship and the community,"

said Mr. Superio in his acceptance speech.

The SEAFDEC/AQD Library has been an ASLP institutional member since 2011.

COVID-19 measures

This year, the Coronavirus disease (COVID-19) pandemic still posed challenges to the lives and work of people around the world. To mitigate the risk and impact of the pandemic to SEAFDEC/AQD's workforce and operations, vaccination was promoted and facilitated. By the end of 2021, 294 out of the 305 personnel were already fully vaccinated. Agency-hired personnel such as the security guards and janitors were also included in the vaccination drive. Out of the 43 agency-hired personnel, 32 were already fully vaccinated.

Official guidelines on the management of COVID-19 cases was also issued to provide procedures in handling cases. RT-PCR pool testing was also conducted for employees, especially among drivers, messengers, and those occupying shared housing units.

Safety kits were also distributed to newly-hired employees. The kits included vitamins, medications, a thermometer, an oximeter, masks, and alcohol.



Seminar-workshop on proper cleaning and disinfection techniques



Vaccine literacy program

Staff development

To enhance and upgrade the knowledge and skills of its employees, SEAFDEC/AQD supports for the attendance and participation of qualified and deserving staff in local and international meetings and conferences through the Staff Development. This year, four personnel attended the online event 44th Larval Fish Conference and one personnel attended virtually the 18th International Conference on Fisheries and Aquaculture (ICFA 2021).



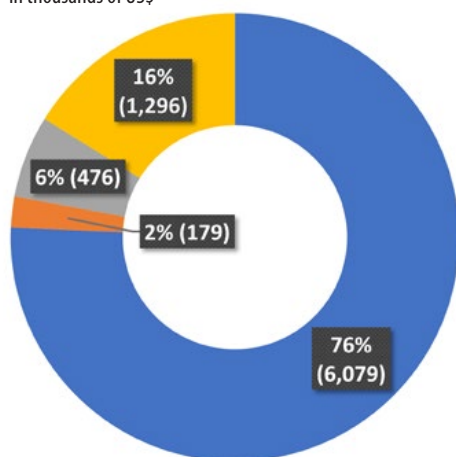
With this photo with a giant white marlin, Associate Researcher Ma. Irene Legaspi won third place in the 44th Larval Fish Conference photo contest. Her attendance was supported by SEAFDEC/AQD's Staff Development Program.

Summary of grants received

Organization	Scope	Amount (USD)
Bureau of Fisheries and Aquatic Resources	Preparation of feasibility studies of Multi-species Marine Hatchery (January-December 2021)	39,565
Australian Centre for International Agricultural Research (ACIAR)	Increasing technical skills supporting community-based sea cucumber production in Vietnam and the Philippines (Oct 2019-Dec 2021)	37,606
Japan International Research Center for Agricultural Sciences (JIRCAS)	Demonstration and verification of sustainable and efficient aquaculture techniques by combination of multiple organisms (Jan-Dec 2021)	16,566
Bureau of Fisheries and Aquatic Resources	Feasibility studies for the Establishment of Legislated Hatcheries in Region 6 (May-Dec 2021)	39,565
The Scottish Association for Marine Science (SAMS)	Safeguarding the future of the Seaweed Industry in the Philippines: Disease and Pest Detection (Jan-Dec 2021)	13,789
Panay Aquafarmers Consumers Cooperative	Establishing an Aquaculture Feed Mill Plant & Operating the Said Plant in the Province of Capiz (Aug-Dec 2021)	2,967
SEAFDEC-MFRDMD	Co-Location of Repository Servers (Sept-Dec 2021)	9,976
SEAFDEC-Secretariat and Training Department	Co-Location of Repository Servers (Sept-Dec 2021)	19,968
Department of Science and Technology (PCAARRD)	Molecular mechanism underlying Scylla serrata response to white spot syndrome virus (WSSV) infection (Jan-Dec 2020)	872
TOTAL		180,874

2021 Sources of funds

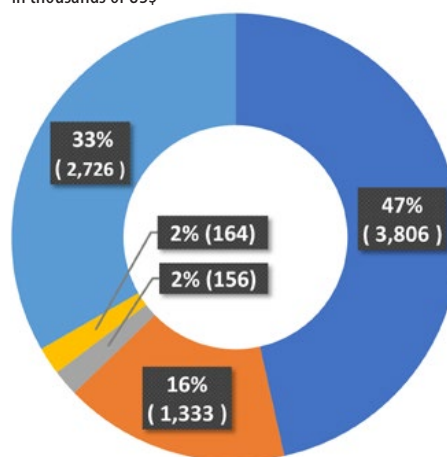
in thousands of US\$



- Government of the Philippines
- External Grants
- Internally-generated Income
- Committed funds from prior year

2021 Application of funds

in thousands of US\$



- General/Admin & Non-project expenses
- Program/Project Expenses
- Projects of GOJ-TF
- Externally-funded projects
- Committed funds

Statement of Sources and Application of Funds

SOURCES OF FUNDS	USD	APPLICATION OF FUNDS	USD
Contributions from the Government of the Philippines	6,078,551	General/Administrative & Non-project Expenses	
Government of Japan Trust Fund (GOJ-TF)		Research Division (RD)	1,471,551
Development of strategies and technologies for aquaculture production in Southeast Asia	45,000	Technology Verification & Extension Division (TVED)	94,060
Development of procedures in disease control and management against shrimp and fish disease in Southeast Asia	40,000	Training and Information Division (TID)	774,587
Capacity Enhancement on Sustainable Aquaculture and Aquatic Animal Health Management in Southeast Asia	30,000	Administrative & Finance Division (AFD)	1,185,172
Progress Management of Project	40,799	Management Group (MG)	280,255
Sub-total	6,234,350	Sub-total	3,805,624
External Grants		Program/Project expenses	
BFAR-Conduct and preparation of feasibility studies and related documents for 3 multi-species hatchery/nursery projects	39,216	RD	188,579
DOST PCAARRD- Molecular mechanisms underlying <i>Syella serrata</i> response to WSSV	864	TVED	310,564
ACIAR (USC)-Increasing technical skills supporting community-based sea cucumber production in Viet Nam and Philippines	37,275	TID	834,185
SAMS- Global SeaweedsSTAR	13,668	Sub-total	1,333,329
JIRCAS- Demonstration and verification of sustainable and efficient aquaculture techniques	16,420	Projects of GOJ-TF	
SEC/TD/MFRDMD- Co-location of repository servers	29,649	Development of strategies and technologies for aquaculture production in Southeast Asia	46,855
BFAR- Conduct and preparation of feasibility studies and related documents for 3 multi-species marine central hatchery, 2 multi-species marine satellite hatchery and 1 multi-species freshwater satellite hatchery.	39,216	Development of procedures in disease control and management against shrimp and fish disease in Southeast Asia	41,655
PAFCC- Preparation of feasibility studies and related documents of Feed Mill in Capiz, Iloilo	2,941	Capacity Enhancement on Sustainable Aquaculture and Aquatic Animal Health Management in Southeast Asia	26,540
Sub-total	179,250	Progress Management of Project	40,790
Internally generated		Sub-total	155,840
Research Division	105,866	Externally-funded projects	
Training & Information Division	34,211	BFAR	11,817
Technology Verification & Extension Division	265,646	NFRDI	58,603
Administrative & Finance Division	70,161	DSM Nutritional Products Phil. Inc.	243
Management Group	118	SAMS	19,681
Sub-total	476,002	ACIAR	51,367
		JIRCAS	16,864
Committed funds from prior year	1,295,844	DOST	1,762
TOTAL SOURCES OF FUNDS	8,185,445	PAFCC	3,821
		Sub-total	164,157
		Committed Funds	
		On-going activities	469,301
		Capital outlay/repairs	2,257,194
		Sub-total	2,726,495
		TOTAL	8,185,445

Note: US\$1.00 = PHP50.999

COLLABORATION IN 2021

Academe

Partner Institution	Nature of collaboration	Period
Western Philippines University	On-the-Job Training Program	27 Jan 2016– 26 Jan 2021
John B. Lacson Foundation Maritime University-Arevalo	Research collaboration	17 Feb 2017– 31 Jan 2022
St. Paul University Iloilo	Collaboration in undertaking research, instruction, training, and extension programs	25 Oct 2019– 24 Oct 2024

Government and Non-Government Organizations

Partner Institution	Nature of collaboration	Period
Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR)	Conduct assessment of existing hatcheries in the region; Prepare plans and cost estimates of identified priority hatchery for rehabilitation; Extend necessary technical assistance in the hatchery operation	09 Mar 2021– 31 Dec 2021
Panay Aqua Farmers Consumers Cooperative (PAFCC)	Planning and set-up of low-cost feed mill in Capiz Province	Sep 2021– Jan 2024
Mindanao Development Authority (MinDa)	Conduct training in broodstock, hatchery, nursery, and grow-out operations of commercially viable finfishes, crustaceans, mollusks, and seaweeds	2021–2024
BFAR Region 6	Conduct an assessment of existing hatcheries in the region, prepare plans and cost estimates of identified priority hatchery for rehabilitation, and extend necessary technical assistance in the hatchery operation	2020–2025
Japan International Research Center for Agricultural Sciences (JIRCAS)	Provide technical assistance to visiting scientist from JIRCAS	14 July 2016– 31 March 2021
Scottish Association for Marine Science	Conduct of the research project on "Safeguarding the Future of the Seaweed Industry in the Philippines"	01 Oct 2017– 31 Dec. 2021
National Fisheries Research and Development Institute (NFRDI)	Aquaculture Feed Development in the Philippines: Assessment of raw materials and alternative to fishmeal; Feed formulation using low cost raw materials and feed ingredients; Pilot testing of the formulated feeds; Conduct training on feed preparation and feed formulation	July 2018– June 2021
NFRDI	Aquafeed Research, Development and Extension Project (ARDEP): Cooperating Agency and member of the Technical Working Group in the implementation of the project; Submit proposal on the aquafeed research, development and extension; Conduct and implement the study in accordance with the approved Project Proposal	Sep 2018– Dec 2022

HEADS OF OFFICES IN 2021

Executive Committee

Chief	Mr. Dan Baliao
Deputy Chief	Dr. Sayaka Ito
Head, Research Division	Dr. Leobert de la Peña
Head, Technology Verification & Extension Division	Dr. Roger Edward Mamauag
Head, Training & Information Division	Dr. Edgar Amar
Head, Administration & Finance Division	Ms. Amelita Subosa

Program Leaders

Quality Seed for Sustainable Aquaculture	Dr. Maria Rowena Eguia
Healthy & Wholesome Aquaculture	Dr. Mae Catacutan, Dr. Eleonor Tendencia
Maintaining Environmental Integrity through Responsible Aquaculture	Dr. Jon Altamirano
Meeting Social & Economic Challenges in Aquaculture	Dr. Nerissa Salayo
Regional Programs	Dr. Sayaka Ito

Station Heads/OIC

Binangonan Freshwater Station	Dr. Frolan Aya
Dumangas Brackishwater Station	Mr. Victor Emmanuel Estilo (until 30 April 2021) Dr. Roger Edward Mamauag (beginning 1 May 2021)
Igang Marine Station	Mr. Mateo Paquito Yap
Manila Office	Ms. Christine Joy Catig

Section Heads/OIC

Research Division

Breeding & Seed Production	Dr. Shelah Mae Ursua
Fish Health	Dr. Eleonor Tendencia
Nutrition & Feed Development	Mr. Joseph Biñas
Farming Systems & Ecology	Dr. Jon Altamirano
Socioeconomics	Dr. Nerissa Salayo

Technology Verification & Extension Division

Technology Verification	Dr. Roger Edward Mamauag
Extension & Packaging	Ms. Erish Estante

Training & Information Division

Training	Mr. Caryl Vincent Genzola
Development Communication	Mr. Rex Delsar Dianala
Library & Databanking Services	Mr. Stephen Alayon

Administration & Finance Division

Engineering	Engr. Hermoso Igcasan Jr.
Human Resources Management	Ms. Sunshine Mae Salonga
Budget-Cashiering	Ms. Jiji Rillo
Accounting	Ms. Jo Anne S. Coronel (until 30 Sep. 2021) Mr. Isiah Keish Torres (beginning 1 Oct. 2021)

PRIORITY INFRASTRUCTURE PROJECTS



Milkfish broodstock tanks and visit of Department of Agriculture Sec. William Dar in December 2021 (right)



Multi-species marine hatchery and visit of Department of Agriculture Sec. William Dar in December 2021 (right)



Multi-species freshwater hatchery and visit of Department of Agriculture Sec. William Dar in December 2021 (right)



Feed Mill

Multi-species
Freshwater
Hatchery

Multi-species
Marine
Hatchery

Marine
Hatchery
Extension

Shrimp
Broodstock
Facility

Milkfish
Broodstock
Tanks

Liner ponds

Water Treatment
Tank

COMPLETED AND PROPOSED INFRASTRUCTURE PROJECTS AT TIGBAUAN MAIN STATION

Completed —●—
Proposed - -○- -
as of December 2021



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

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in December 1967 to promote fisheries development in the region. The member countries are Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam.

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

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

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

AQD is mandated to:

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

SEAFDEC/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. SEAFDEC/AQD also has a Manila Office in Quezon City.