TARS 2017 Meeting Report

THE AQUACULTURE ROUNDTABLESERIES® 2017

A shared vision for aquaculture in Asia

August 16-17 2017, Bali, Indonesia

Finfish Aquaculture: Strategies for Growth

Organised by Aqua Culture Asia Pacific & and Corporate Media Services, Singapore.

Tars 2017
Finfish Aquaculture: Strategies for Growth

Dr Coco Kokarkin Soetrisno, gave the welcome remarks

The 7th Aquaculture Roundtable Series (TARS) 2017 was held in Bali, Indonesia, from 16-17 August 2017. There were 180 participants, with 27% from Indonesia. While TARS 2013 reviewed issues related to production and supply chain for this industry, this year the meeting addressed growth prospects, trends, opportunties and challenges. The welcome address was presented by **Dr Coco Kokarkin Soetrisno**, Director of Seed Development at the Directorate General of Aquaculture, Ministry of Marine Affairs and Fisheries, the authority in charge of aquaculture planning, R&D, extension and regulatory affairs throughout the archipelago.

The plenary at TARS 2017 had five sessions, covering;

- state of industry and challenges;
- a new realm for the Asian white fish;
- production, health and environment;
- performance feeds and cost efficiency, and
- new frontiers in finfish farming.

During the interactive breakout roundtable session, participants deliberated on strategies for growth via production efficiency and industrialisation; performance and functional feeds and marketing image and sustainability.

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State of industry on finfish farming in Asia: Development areas and reputation management

This is a signature of TARS to set the stage for the plenary session. **Dr Einar Wathne**, President and CEO of Cargill Aqua Nutrition (CQN) presented on developments, bottlenecks, directions and challenges based on his subjective experiences and learning after more than 30 years in the aquaculture industry. He started with an insight on a consumer survey on the white fish in the US which Cargill conducted in May/June 2017. The results of the survey revealed:

- 72% of the US consumers believe seafood is important for their health and nutrition;
- 88% are likely to buy and pay more for seafood certified as sustainable and responsibly sourced;
- 70% said that where the seafood is sourced impacts their purchasing decision; and
- 50% prefer to buy wild caught fish instead of farmed fish.

"Our challenge is the last point and that in terms of species, many (27%) recognise salmon whilst only 8% recognise tilapia as a species on the seafood plate," said Einar.

A comparison of markets for tilapia and the salmon showed that international trade for the tilapia is still much smaller than that of the salmon which means that there is a high local consumption. There is a high potential in Western markets for the tilapia, although currently, it does not feature in the EU market. Even in America, the penetration of tilapia is small. However, China is now a growth leader in the whitefish market.

While supply will grow from Southeast Asian farms, here too demand is high and domestic consumption is rising. In the future, we believe that Brazil might fulfil the needs of China."

Fundamentals in production

There are three pillars in production: health, nutrition and genetics and breeding. Fish health is fundamental to market access and license to grow, and for the industry to deliver the expectations of the society. Diseases restrain aquaculture growth for nearly all species and increase production costs. To fulfil our promise to supply seafood to the world, we will need to manage health issues.

"We know that the tilapia is a robust species and yet average mortality in a life cycle is more than 35%. Over stocking is common for higher harvest for higher biomass as juveniles are cheap. Farmers see this numbers game and choose to invest in juveniles instead of nutrition and health to reduce mortalities," said Einar.

There are three aspects of nutrition which together will bring feed costs down, fish quality and feed performance up.

- Precision nutrition uses science and involves nutrient supply and nutrient demand. Nutrient supply of the various ingredient matrix should precisely match nutrient demand of fish farmed in different environments.
- Smart feeding is applying technology and using information on demand with different species, environments and life stages.
- Novel ingredients involve industrial innovation.

Einar's take on genetics and breeding is, "One difference between aquaculture and livestock is that we have genetic programs at the species level and there are 240 species being farmed and only 13 species with more than 1 million tonnes production. We need to make a choice which are the species to tackle as we cannot do a genetics program for all. We have seen genetic gains in growth, disease resistance and survival.

"Sound genetic work is high tech and is not for everyone as it requires huge investments. There are already large global players and local players in Asia itself. Maturing industries are expected to be dominated by relatively few providers of improved seed, with highly specialised competence in genetics and selection. There are decisions to be made on the traits to select too," added Einar.

Sustainability and traceability

The emphasis was on the need to address the whole value chain. There are three components: economic, environmental which is doing more with less, and social licence which may be the most difficult. "Aquaculture is not just about fish production, it is about satisfying consumers. People want to know more about their food: what it is made from, where it is made and how it is made. This is no longer a demand from affluent western markets, but spreading to all consumer markets," said Einar.

"My message is that sustainability and traceability are prerequisites from feed to plate."

Reputation management

As an industry, we need to manage our reputation well. Einar emphasised, "This is our asset. However, first we need to recognise that we are in a transparent market today and there is speed in information." Einar illustrated this with some reputational issues with the tilapia and pangasius.

"What is done in one country affects another country. There should be industry collaboration and we need the critical skill to manage our reputation in a transparent market with speedy and borderless information."

His key takeaway was, "We need to acknowledge the issue. Transparency, communication and industry collaboration are key elements."

Growing finfish in Indonesia

Indonesia is the third largest producer of farmed fish, after China and India. It also has the world's largest tilapia farm. Finfish production rose to 3.7 million tonnes in 2015. Most of the farming activity is in the western part of the country producing 2.9 million tonnes.

In his presentation on 'Growing Finfish in Indonesia', **Dr Erwin Suwendi**, Head of Nutrition and QC, PT Suri Tani Pemuka, Aquaculture Division of JAPFA Group in Indonesia, described the structure of the industry. Tilapia is the major species at 1.09 million tonnes of production in 2015, followed by the *Clarias* catfish at 719,000 tonnes, a relatively cheap fish for local consumption. Next is the common carp at 461,500 tonnes and pangasius at 339,100 tonnes in 2015. Seed stock are from public and private hatcheries; large scale and backyard hatcheries. Nursery culture is common for groupers, tilapia, milkfish, catfish, common carp, gourami and pangasius. The four-stage tilapia nursery is from larvae to a final size of 8-12 cm after 60 days. Almost all grow-out systems are monoculture, from low to high density.

"Production is mainly for local wet markets and food service outlets where fried fish is the main product. Exports are fish fillet and value-added products. Fluctuations of demand and price are common and are correlated to festival periods," said Erwin.

"In the feed industry, among the 49 registered aqua feed producers, there is awareness on the need to replace fish meal for sustainable feed production. In fact, Japfa is the first company to produce low phosphorus tilapia feed to address the impact of this nutrient on the environment. It is the only company from Indonesia invited to participate in the Free Fishmeal/Fishoil Feed (F3) challenge in the US.

Meeting targets

In his SWOT analysis on the industry, Erwin identified several strengths, from high species diversity with ten commercial finfish species, strong government support, affordable and willing manpower to work in remote places, availability of local feeds and locally manufactured equipment such as cages. The Indonesia National Standard has codes of practices along the supply chain (genetics, brood stock, hatcheries, nursery, grow-out and feed) for several species. Currently all of these are present for grouper, tilapia, common carp, pangasius and *Clarias* catfish.

Two major weaknesses are in seed quality and availability and farmer capability. In terms of opportunities, there is large potential for investment in freshwater and marine aquaculture in the eastern and central regions of the country. "The future of Indonesian aquaculture is also in sustainable and responsible off-shore mariculture," said Erwin. The domestic market is large. But, in marketing, the multiple supply chains also mean that prices are high for the end consumer.

"We will need to focus on the threats, mainly disease outbreaks from *Aeromonas hydrophila*, *Streptococcus agalactiae* and *S. inae* occurring during the rainy season. Others include environmental pollution, land and water conflicts such as use of lakes for tourism."

Fish production, mainly freshwater fish, is also for national security. Our challenge is the intense competition with most Asean countries producing the same species. To survive, we just need to be unique and different."

Erwin concluded, "Overall, our industry is seeing a growing momentum to learn from the past, educate farmers and influence market demand; it is calling for more responsible and sustainable methods to grow future finfish production via technology and a nutritional holistic approach. Cooperative work and collaborative research are absolutely needed among aquaculture stakeholders: farmers, private sector as well as government in order to minimise or resolve the problems."

Challenges in China's finfish farming

Dr Niels Alsted (BioMar Group A/S, Denmark, Business Relations and Technical Director) spent a year in China and frequently visiting China during the last 10 years. His presentation on the industry in China reflects his experiences in China's fish feed world.

Aquaculture in China is varied, with more than 100 species in production. Farmers have considerable experience in handling water and farming conditions. In terms of volume, farming is dominated by the cyprinids, but farming of other species such as bass, pomfret and croaker is growing, as a result of the demand from a growing well-to-do population.

The fish feed industry comprises numerous small and medium size companies and a few big feed producers supplying mainly small family farming units, with the majority using low cost feeds. "Only the larger companies have the scale to carry out R&D to support the development of feed and farming. The feed price is the main contention, especially among the small producers."

Huge demand for finfish

There is a lot of strengths in the industry. Among them, farmers are flexible and work fast to swap species. There is a huge demand for farmed fish and fish is highly valued as a food item. Weaknesses include access to water (in terms of quantity and quality) and poor control of farming conditions.

Niels said that opportunities revolve around access to water and its quality. "New technologies such as simple to complex recirculation aquaculture systems (RAS) were recently introduced. This development requires the use of efficient feed and technical knowledge more professionalism in the sector."

Climate change giving rise to more extreme weather conditions, temperature fluctuations and flooding is a perpetual threat in the south. These in combination with poor water management lead to disease situations which could explode. Consumer focus on food safety and farming conditions could mean imposition of environmental regulations to control discharge of nutrients (nitrogen, phosphorus etc).

There is a huge need in China to switch from the use of trash fish to pelleted feeds. This will require stricter enforcement of food safety regulations, the environmental footprint and a more transparent chain from raw materials all the way to the consumers.

An important issue is building trust between the farmer and the feed miller. "Raw material price variability leads to necessary changes in formulation which could change feed colour or smell without affecting performance. Many farmers see these as attempts by the feed miller to increase profits at their expense. In China, we see the initial change in focus from protein to digestible protein.

"It is difficult to sell higher performance and thus higher cost feeds. If there are no environmental regulations to restrict environmental pollution, feeds with lower discharge of nutrients will not be readily accepted and could add to cost of production. With limited documentation at the farm level, no farmer will pay extra for feed. The reality is that because of the lack of control in water and pond management, water quality will affect the performance more than feed would." The need for improving both farming conditions goes hand in hand with more effective and competitive feed.

"It is all about water management and adapted feed. There is a lot of interest in RAS systems but it does not mean that the conventional system has to be abandoned. Rather, some of the advanced technologies can be applied to existing systems and it is important to be able to evaluate the weaknesses of an existing system."

His message was that the more exigent segment of the population will demand for safe and sustainable food and this requires a new approach to feed as well as farming. China is on its way to make these changes as there are no other alternatives.

Challenges faced by a marine finfish farming business

In Malaysia, the IKS group, started in 1997 as KS Aquaculture, a company formed by three farmers with 20 net cages in Pulau Ketam, Selangor in Peninsula Malaysia. Today, it has a total of 7,482 cages covering 154,000 m^2.

In 2016, production comprised 50% of red snappers *Lutjanus malabaricus*, 20% groupers (tiger *Epinephelus fuscoguttatus*, giant *E. lanceolatus* and tiger x giant grouper hybrid) and 10% of pompano *Trachinotus sp*. Other farmed species include the golden snapper *L. johnii* and Asian seabass *Lates calcarifer*. The yearly fish production is 1,250 tonnes of marketable fish and 5 million of 2-inch (<5cm) fry.

Laura Khor Li Imm, Quality Control Manager at KS Aquaculture highlighted the challenges faced by fish farmers in the group in keeping up with environmental and market changes. Her task at the group level is to bring the company to a sustainable level and according to Laura, a considerable amount of the time is spent on monitoring disease outbreaks and environmental conditions.

"Both survival and growth at grow-out have declined significantly. This is common across almost all of our grouper species. Growth has also suffered - we used to get a 22 kg giant grouper after 4 years of grow-out. But today, we get a 12 kg fish after 4 years and 18 kg fish after 5 years."

Natural phenomena indicative of climate change have been a bane for the farmers. "These include phytoplankton blooms which destroyed market-size stock in cages in Johor. Our sampling of the phytoplankton showed the presence of red tide algae species, dinoflagellates and diatoms causing clogging of gills. There were also instances of mass fish mortality where we could not identify the cause," added Laura.

Production planning and challenges

Farms avoid extremes in water pH and dissolved oxygen (DO), fluctuations when stocking. "Traditional farmers will also avoid the lunar full and new moon when the current velocity is highest. They also try their best to avoid periods with the higher possibility of parasite infestations, especially of *Benedenia* sp.

"The other challenge is planning harvesting to meet customer demands, highest during the lunar new year week (usually in late January to early February). For example, it takes a year to grow the red snapper to 600g fish and so stocking should start a year earlier. A lack of manpower also poses limitations in managing the health of fish stock in a large farm."

Farmers are not able to raise current fish prices in tandem with the rising costs of feed and fry, due to more competitive prices of wild catch. "In 2016, we saw a 31% increase in feed cost and 188% increase in trash fish prices. Farmers still depend on trash fish for the grouper which give faster growth.

"We have a supply shortage of affordable grouper fry that are free from pathogens and able to tolerate the conditions of the cage farm after being reared in the protected hatchery environment.

"Over the years, farmers have also observed 70% more disease outbreaks compared to 15 years ago, associated with poor nutritional health, parasites, secondary bacterial infections and viruses carried by infected fry," said Laura.

These are parasitic, Benedenia sp, Dactylogyrus, Polyopisthocotylea (Microcotyle), isopods, bacteria, *Vibrio alginolyticus, V. parahaemolyticus,Tenacibaculum maritimum, Nocardia* sp, Lymphocystis. Iridovirus outbreaks are responsible for high mortality of up to 60-80% in grouper, red snapper and red drum. The greatest fear is nervous necrosis virus (NNV) which could result up to 90% mortality in groupers when temperature rises.

The group is on its way to obtain farm certifications which will require constant testing of water, feed and fish. It is adjusting SOPs to match limitations in staff and its traditional farming structure. Adapting to changing market conditions, KS now offers online sales to local customers. Laura sees a need for change, "We really need to transform traditional culture practices towards more sustainable methods in the face of changing demands and environment."

Lessons from the Mediterranean marine fish farming: Strategies with competition

Hervé Lucien-Brun, Jefo Aquaculture Consultant had the role of explaining developments and how producers rationalise their fixed cost in this very competitive market. These developments in the Mediterranean are lessons to learn for the industry in Asia.

"In the 1990s, we opened the bottleneck in fry and fingerlings which previously came from hatcheries in France or were wild caught. Farmed production of seabass and seabream increased at a rate of 30 % per year between 1992 and 2002 and induced a dramatic fall in prices. The ex-farm prices of both species decreased by approximately 60% between 1990 and 2000. Currently, prices fluctuate between €4.6 and €3.8/kg.

"The industry had to rationalise the fixed costs. The first impact was on the small farms with 5-10 cages. We saw business bankruptcies."

Reduction of fixed costs came with acquisitions and consolidation of farms. The number of companies producing marine fish fell from 430 to less than 40 in 2016. There was integration along the supply chain. In Turkey, Kilic Deniz increased production by 26% between 2004 to 2014 and exported to 40 countries. In France, the much smaller but totally integrated Gloria Maris, produces almost 80% of the French farmed marine fish. Expansion was possible in Greece and Turkey where there is a balance between tourism with aquaculture.

"With low prices, farms needed to improve on costs of operation to remain competitive. They had to adopt strategies to improve feed conversion ratios. FCR was reduced from 1.8-2.2:1 to 1.4-1.6:1 for portion size fish (500 g fish). In larger fish (>1 kg), the FCR came down to 2.2:1 from 3:1. Feed producers made a strong effort to reduce part of fish meal and fish oil in the feed. Only extruded feeds were used. In feed management, automation was introduced. Fingerlings were produced in specialised hatcheries to optimise production cost," said Herve.

Companies shifted to produce large 3-4 kg fish, filleting and developing product forms for a new generation of consumers. Renown chefs assisted in promotional campaigns to expand markets. The focus was also on country of origin to encourage national pride in local products.

His message was, "Any drop in prices is always a no-win situation and possible ways to regain markets are branded products with differentiation based on origin, quality and certification."

Increasing value through technology

Dr Olivier Decamp, Farm & Feedmill Product Manager at INVE Aquaculture, discussed how can R&D and technology make a difference in tilapia farming. Like any aquaculture species, tilapia producers face challenges along the supply chain such as environmental impact, diseases and the perception as a healthy food.

Along the value chain

Decamp started his presentation with a plea for a holistic approach in the tilapia culture value chain: "Let's start by looking at the value chain to identify the areas that can be improved. Under optimal conditions the culture cycle can be shortened. This will increase yearly production and, as a secondary benefit, better disease control. Two other areas we can still develop are the reliability of supply (especially through broodstock management) and the image of tilapia as healthy white fish. In this respect, we need to make sure tilapia does not come to face the same problems as pangasius.

"Whether it is nutrition, health or environment related, every problem is a challenge to find the right solution. Technology is available, but it should not be used as a band aid or to come up with stand-alone quick fixes. We really need to embrace a holistic approach if we want to improve the industry."

Looking at the production cycle, a specific objective for the broodstock stage is to get a more predictable output of good quality fry per female. Genetic selection is critical, but not sufficient. Research showed clear benefits of optimised nutrition on the percentage of females spawning, with a +20% production increase of viable eggs. Furthermore, adequate nutrition reduces the seasonal decline in weekly egg production.

"The target should be to increase egg output while improving predictability. To prevent vertical transmission of pathogens such as *Streptococcus agalactiae* and *S. iniae*, we will need to implement biosecurity measures and work with screened broodstock and disinfected eggs. Compared to a year ago, we now have access to fast diagnostic tools to screen for TiLV. Another important step is to work with safe and qualitative products to avoid the introduction of pathogens or contaminants."

In the hatchery, sex reversal is a stressful phase for the larvae. Optimized condition in this stage will result in better higher survival going onto the nursery.

In the nursery, survival varies with location, climate, quality and genetics of the fry, number of phases, etc. Examples include 70% from swimming fry to 1g, 95% from 0.2g to 20g and 60% from 1g to 5g.

"Nursery operators understand that improving conditions can make a difference. Therefore, they will accept the extra cost of good booster feeds and water treatment, as it is critical in the nursery stage to prepare the animals for the stress of the transfer onto the farm."

Nutrition and feeding management is linked to rearing conditions, tilapia strain and cost constraint. Protocols including vaccination, control of rearing conditions, and performance enhancer diets or additives will help.

There is a link between what happens at the farm and marketing. "In the case of the tilapia, getting rid of off-flavour is important. Protocols do exist to control off-flavour in pond-based and RAS-based systems."

"In conclusion, we need to learn to increase value through a holistic approach. We need to exploit the interaction between key components: genetics, nutrition, health and environmental management. Usually we tend to work in silos and do not link parts of the value chain. We need to work on the whole supply chain and transfer benefits from one phase to the next for optimal cumulative gains."

Moving up the whitefish ladder

In this presentation, **Jonathan Forrest Wilson**, Executive Director Godaco Seafood JSC, Vietnam, discussed the need to grow the value of the pangasius through value added production. Godaco is a fully integrated company in pangasius; from fry, feedmill, grow-out to cooked products. "Vietnam produces an overwhelming majority of the globally traded pangasius products. Therefore, it makes sense to talk about the evolution of value added pangasius in the context of the Vietnamese experience, economy and industry."

Today, Vietnam's output of pangasius is 1.2 million tonnes, 80% of global production. It has come a long way, to be an international product farmed and processed under certified standards and modern processing techniques.

Wild ride for producers

"However, for the producer, it was a wild ride since 2007; lower prices with over supply typical of any commodity. Prices in Europe have declined since 2013 linked with various issues. Oversupply is one reason but many instances it is due to bad press. Our challenge has been coping with one crisis after another. One way forward is to increase productivity and the other to go downstream with cooked products," said Jonathan.

"The US market, although a target, has become restrictive with tariffs and 100% inspection holding up consignments. Producers are looking for Asian and Middle East markets to expand. In Q1 2017, China was the leading importer. It is easy to enter China which focuses on food safety but there is little demand for sustainability which we have been investing and working hard to be certified by ASC etc ."

Up the value chain

As a commodity the pangasius competes in the low-cost whitefish arena. Vietnam exports most of its pangasius as white fillet. Several integrated producers are trying to advance and drive value through further integration by moving up the value chain, by coating and in some cases even cooking. Some 65-70% of the volume imported into the UK is value added, coated marinated or blended in the UK for retail and food service distribution. In UK supermarkets, value added pangasius or basa sits alongside premium white fish such as the cod.

"Vietnam's pangasius can move up the value ladder designing food for the developed world rather than selling just raw material."

Bringing the value added processing back to point of processing rather than doing it in the importing country will generate benefits for industry's productivity and growth but also more sustainable and better yields for the people of Vietnam."

However, this is still a long journey ahead. The message was, "We are no longer in the frozen fish business, we are in the frozen food business and that is a bigger pond of profits."

Palatability drivers in fish diets: From modes of action to applications for quantifiable enhanced feed and fish performances.

Dr Philippe Sourd, Global Technical and Sales Director, Diana Aqua – Aquativ, France discussed the modes of actions for quantifiable enhanced feed and fish performances.

Feed intake is the very first driver of a diet performance in a fish farm. "Aqua feed formulations are entirely focussed on meeting the nutritional and physiological requirements of fish for performance and economic targets. The best feed formulations will not deliver any results if feed is not consumed in the first place!" said Philippe. Feed intake is a combination of attractability and palatability.

Attractability, will elicit faster feeding but not necessarily increase consumption. For the feed miller, diet palatability thus remains crucial because feeding behaviour is the first criterion customers will notice. Palatability is the capacity to stimulate fish appetite and make the fish eat the feed. The more palatable the feed, the more the fish will eat. Feed intake (and feeding behaviour) results from complex interactions between the diet, the fish and its (temperature, oxygen, density, stress etc.)

"Amino acid profiles will impact palatability. The formulator, must consider this when choosing raw materials. In a trial, enhancing palatability with a crustacean hydrolysate, feed intake increased by 3% with the tilapia, whereas it increased by 20% with the European seabass. Therefore, omnivorous and carnivorous fish do not require the same level of feed palatability. We also showed a preference for raw material when the European seabass responded better to crustacean hydrolysate instead of a mixture of tuna/ crustacean hydrolysates," said Philippe. "The origin of the oils does not matter to fish. There is no difference in performance with fish or plant oils or even a blend of oils."

Studies showed that high levels of free amino acids stimulate feeding behaviour in fish but hydrolysates which combine both peptides and free amino acids have better palatability due to the peptides effects within the digestive system. "There is no benefit in boosting hydrolysates with extra free amino acids. Peptides trigger functional responses regulating from food intake, digestion, gut motility, metabolism and absorption.

Several fish species can regulate their appetite according to energy or protein levels in the diet to meet their metabolic requirement. Besides formulation, it is obvious that very hard pellet or excessively strong pellet texture can slow down food transition.

Species are all different. Palatability should be built around them. Sourd showed a model of a palatability 'wheel' where there is much more to investigate. Snakehead, tilapia, seabass, catfish may be more or less responsive to factors such as pellet humidity, pellet texture, pellet shape or size, energy or protein content, colour etc. .

Deploying palatability enhancers

"How can we deploy them successfully to achieve higher intake, reduce feed waste in the environment as well as save staff time in feeding?

In an overwintering trial for the tilapia, Philippe said that the inclusion of crustacean hydrolysates raised feed intake to 20% at 20°C, demonstrating how environment conditions can affect results. Palatability enhancers allow for a decrease in performance deviation between feeds from different origin as shown with four diets from different sources.

The type and quality of fish meal content influence feed intake in the Asian and European seabass. In the former, a reduction in the fish meal in isoprotein and isolipid diets from 80% to 0% decreased feed intake considerably. In the latter species, palatability performances of four marine ingredients processed differently scored from 100% for hydrolysates to 30% for a co-product. In turn, the processing of the hydrolysate influences palatability.

In feed processing, coating the palatability enhancer onto pellets maximizes the feed intake and is recommended for the best cost benefit. Dosage is critical and should not be exceeded to be cost effective. Too low a dosage will put performances at risk. As the fish grows, the requirement will decrease, making the solutions still economically viable for large sized fish.

"Buying and adding a palatability enhancer to the diet will not automatically improve the outcome. We need to make the right decisions on the feed design and raw materials selection as well as choice of the palatability enhancer and its dosage and application mode. The feed has to minimize deterrent factors, variability of raw materials and inconsistencies in the feed production process to start with. Farmers expect a standardized response. Therefore, feed producers must use standardized ingredients to obtain secure solutions."

Parasite prevention in fish farming

On behalf of Nutriad International **Professor Francisco E Montero**, University of Valencia, Spain discussed fish-parasite interactions for the implementation of better control measures. This includedstudies on parasite biology and epidemiology.

"Each aqua species is prone to different parasites. When parasites leave the fish farm, they can infect wild fish and generate all sorts of problems. The abuse of chemicals used for treatments affect the environment and raises questions on food safety. To reduce the impact of parasites on productivity as well as to address the adverse public perception on farmed fish, preventive measures are key in fish farming.

"In fish farming, usually in open environments, parasitic disease pressure is always present. Primary or secondary parasites facilitate infections while the opportunistic parasites 'make matters worse'.

The 'life-style' i.e. attachment and feeding behaviour of fish pathogens explain their pathological effects on fish. "We need to have the knowledge on how they attach to the host. How and what do they feed on?" The parasite may disturb tissue functionality and steal the food of fish. With a series of graphics Francisco demonstrated the damage mechanism of parasites at the skin, muscle, gut and gills. Several scanning electron microscopy pictures demonstrated the attachment mechanisms of several ectoparasites, from the monogeneans to parasitic arthropods comprising copepods and isopods.

Parasites look for long term host-parasite relations. They attach and invade and they feed on the host tissues thus affecting the host's functionality and then they sometimes release toxins. Isopods extend a part of their bodies into the fish and tear off the skin of fish. Monogeneans affect the skin, gills and natural cavities. They attach and feed, and will continue to actively attach if the fish remains alive. Their preference is the 'better don't kill your host' approach. Outbreaks are related to the dramatic amplication of parasites during some abnormal situations, where the host-parasite balance is destroyed. Disturbance of the host-parasite relation triggers mortalities.

Francisco discussed the white spot parasite *Cryptocaryon irritans* in marine fish which attacks the fish both internally and externally and has the infective trophonts and reproductive and resistant tomonts. Monogeneans feed on blood and on mucous and epithelial cells. They are difficult to remove and fish die of

asphyxia. Another example is the blood fluke *Paradeontacylix balearicus* found in greater amberjack *Seriola dumerili* and *Cardicola* spp in the bluefin tuna *Thunnus thynnus*. Once amplified, these parasites infect the gill lamellae and cause severe damage or mortality.

"An open environment is never 100% clean and farms in the vicinity will be sharing pathogens. Farms will need to learn to live with parasites, understand their behaviour and keep pathogens under control," explained Francisco.

Surveillance and monitoring, and knowing the endemic parasite populations and epidemiology will help to predict and control an outbreak. The traditional approach to combat fish parasites, using chemicals and other therapeutics once the parasite outbreak is detected, is hampered by the increasing restrictions on the use of chemicals.

"Today, the direction is on preventive actions without the use of medication. There is some negativity on the latter which has collateral effects including environmental impacts and development of resistance. Good farm management and practices are pivotal to the reduction of stress in fish."

Functional feeds complement optimized nutrition using health promoting additives with natural anti-parasitic action. "Feed additives are 'easy to deliver' solutions that fit perfectly in a preventive approach, with a good potential for positive return on investment. Natural anti-parasitic compounds can be absorbed in the digestive system and circulated in the blood stream to work against internal and external parasites. Overall there is a reduction in the pathogen count and/or pathogenicity as well as a reduced amplification of parasite population by the host."

His message was, "Parasitic disease problems in fish farms will continue to evolve with the industry. We need to learn to cope with them!"

Sustainable aquaculture starts with feed

This is how **Dr Thomas Wilson**, Aquaculture Nutrition Consultant based in Thailand sees the finfish industry progressing with demands on sustainability. His presentation is an extension of the article published in the May/June 2017 issue, titled 'Benefits of feed enzymes for sustainability and responsible aquaculture'.

In his introduction to sustainable aquaculture in the Asian context, Thomas said, "Sustainable aquaculture is a global issue but with local consequences. The emphasis has been on the environment rather than on social and economic sustainability. Buyers coming to Asia looking for seafood are telling us that they want us to reduce fish meal, i.e. fish in: fish out ratios.

"Fish and shrimp do not actually need fish meal. Fish meal may be the most balanced source of nutrients for aquafeeds, but it is not the only source. Animal and plant proteins and lipids can supply everything fish meal does. "We can focus on low trophic species and expand their production without fish meal. FAO data shows we can already produce 940 tonnes of carp with 1 tonne of fish meal and 700 tonnes of carp with 1 tonne of fish oil. But we still have much higher levels of fish meal included in diets for the milkfish, a herbivorous fish! So, some good R&D needs to be done to bring fish meal levels down for milkfish."

Responsible aquaculture

"Sustainability is really a big issue and it is not limited to just reducing the use of fish meal or fish oil. In Asia, we tend to push economic rather than environmental interests to the forefront i.e. investments, local jobs and profits. An area of concern for all is the limited availability of land and water resources. On a per capita basis, Asia's access to freshwater is the lowest at 3.92m^3 as compared to other continents such as Europe at 4.23 m^3. As we are sharing water resources with others, we must return clean water back to the waterways."

The issues with various open aquaculture systems and the effects of external pollution were demonstrated by various news reports on failures and fish die-offs happening around Asia. "We have been focusing on using low cost feeds, possibly with low cost ingredients leading to polluting our own waters. Fortunately, both the Philippines and Indonesia are now trying to maintain aquaculture production and trying to reduce impact on the environment; moving away from sinking to floating feeds, and improving feed quality and feed management.

Thomas said that a number of Asian countries have experienced serious disease outbreaks with aquaculture intensification efforts, but unlike some, he did not believe that intensification should stop. The European salmon feed industry has shown that fish disease can be managed without antibiotics; using properly formulated high quality feeds, with vaccination and use of functional feeds, and by proper environmental management. Asia can benefit a lot by studying and applying the concepts that are transferable to the Asian industry.

Feed and effects on water quality and animal health

Thomas showed a graph from the WorldFish Center which clearly demonstrated that based on nitrogen and phosphorus emissions per tonne of protein produced, warmwater species (pangasius, catfish, shrimp) fare worst that salmonids, although the latter is a carnivorous species with 2-3 years cycle. "The cycle for carps and pangasius is 6-8 months but emissions are higher. Thus, we need to invest in R&D of nutrient requirements, farming and feeding methods to make large improvements."

Feed is the largest contributor to nitrogen into the pond. "Poor palatability and reduced nutrient digestibility increase production cost and reduce profits. Increased organic waste brings about low dissolved oxygen (DO), excessive phosphorus excretion increases risk of 'off-flavour' in fish, and increases the likelihood of disease outbreaks.

In two slides, Thomas showed the following;

- In the tilapia, *Oreochromis niloticus*, protein digestibility declined to 80% at DO of 6.9 ppm and to 40% at DO 3.5 ppm. After 4 weeks, changes in intestinal morphology affected by both diet composition and DO concentration were visible. High soybean meal inclusion caused enteritis-like symptoms that were enhanced at low oxygen conditions and were made permanent under continued hypoxic conditions.
- Growth of Silver perch *Bidyanus bidyanus* slowed when nitrite levels reached 1.43 ppm, which is actually a low level. In freshwater, nitrite toxicity changes blood haemoglobin to methemoglobin, thus reducing the oxygen-carrying capacity of blood. Low DO and anaerobic conditions stops denitrification, which just worsens the problem.

"Levels of oxygen and nitrogen like these are commonly found in farms, yet the research is showing they cause significant declines in growth rates." Thomas said one way to solve this was to try improve digestibility to reduce nutrient wastage, but the Asian industry might not have access to the most digestible ingredients. He discussed improving feed utilization with enzymes: phytase, xylanase, β-glucanase and protease either singly or in combination. Details are available in his article. He concluded that, "Investing in higher quality, more digestible ingredients and feeds pays back by improving water quality and reducing the negative impacts of low dissolved oxygen and high dissolved nitrogen on fish growth, health and survival. Effective feeds and functional feeds are needed for the long-term sustainability of Asian aquaculture, not low-cost feeds."

His message to industry was, "My hope is that one day, we will stop talking about or we will stop using the words 'intensive aquaculture' and 'low cost feeds' in the same sentence because they do not work together."

Nutrition, feed formulation and the commercial field realities

"How can aqua feed manufacturers cope better with these commercial realities?" asked **Professor P Bureau**, Fish Nutrition Research Laboratory, University of Guelph, Canada.

In Asia, we have a large number of species produced, diversity of production systems and strategies used, and differences in market preferences. These factors impel aqua feed manufacturers to produce a diversity of feed types for different fish species. They have to formulate feeds with costly and imperfect ingredients, accept low profit margins and rely on limited public 'knowledge base' for many of these species and feed ingredients.

Dominique proposed three recommendations and urged industry to adopt a more systematic and rational approach:

- Properly identify context and challenges;
- Adopt systematic and rational approaches;
- Invest in monitoring and continuous improvement.

Aqua feed manufacturers do not just impart nutrition and feed technology knowledge, but also knowledge on animal health management, and farming and breeding technology to their clients. "There are a number of activities where feed manufacturers could positively influence how well clients are doing with their farm without large investments. These include providing diagnostics support to your clients, access to preventive measures, such as the use of vaccines or production strategies to mitigate disease, or the use of feed additives which can have an impact on the health management on the farm."

Systematic and rational research

"This step up approach starts with a review on the scientific and technical information already available. In my research group, we use this type of approach: the systematic compilation of data analysis to address multiple questions on feeding formulation, such as effectiveness of fish meal replacement by some ingredients. It can be done, with existing data and, in some cases, we did not have to carry out a single trial.

Next is to try a few concepts at the laboratory level and then move on to a small scale aquatic facility to test the diets and treatments on a small scale. We control conditions to be really sure of the standard response. Field research is more likely to yield variable results and be risky. Proper field research should involve proper replications and that may mean involving and collecting data from multiple clients."

Nutrition and feed technology

At the feed mill, the first focus is nutritional requirement to ensure the best feed specification. The fine characterisation of nutritional requirements can be done through research trials in aquatic facilities but it can also be done through the review of scientific literature, and even through the use of a nutritional model. At TARS 2015, Bureau presented details on the nutritional modelling his team used to develop the International Aquaculture Feed Formulation Database (www.iaffd.com).

"With the number of species that we have and the different life stages and types of feed to formulate, the best way is to do nutritional modelling. This is the most effective and rational way of defining optimal nutritional specification. Next is to characterise feed ingredients. We still refer or rely on proximate analyses to define the quality. Clearly this is no longer sufficient; we have to go down to analysis of the nutrients of the same ingredients which requires digestibility or bioavailability trials or more advanced chemical indicators," said Bureau. "Most companies invest in very significant human and financial resources in QA/QC but the efforts need to be a lot more systematic and focused on understanding the true nutrition value variation in good feed ingredients and finished feeds."

Today in Southeast Asia, more feed manufacturers are aware of the importance of digestibility of nutrients in their feed ingredients. Bureau commented that, "However, the challenge is predicting digestible nutrient (e.g. lipids, phosphorus) contents of balanced feeds formulated to widely different digestible nutrient levels and made with a great variety of ingredients."

An experimental assessment of digestible nutrient level of a certain feed comprising a wide variety of feed ingredients would be too daunting experimentally because all the combinations require testing of all the ingredients at all levels. "Here again, nutritional modeling may also be of great value. We have shown under commercial conditions that the phosphorus and lipid digestibility models that my group developed were really valuable," added Dominique.

"However, the value of these tools is only as good as the calibration. Thus, you have to do your own research yourself, given your species and your condition in order to get good results."

Investing in monitoring and continuous improvement

Aqua feed manufacturers usually use field research to establish feed efficacy. However, data from farms are estimated values and are often sporadic values but aqua feed manufacturers try to make some conclusions. For easy improvements (low-hanging fruit), such as improving feed conversion ratio (FCR) from 2.0 to 1.6, it may not really matter how systematic you are. However, when the search is for small but commercially meaningful improvements, such as improving survival from 65 to 70% or decreasing FCR from 1.6 to 1.4), it is a lot more challenging.

The goal is to collect information more effectively. "In the American dairy industry, data had been collected systematically since 1893 and then shared and compared among industry. The sharing and advanced analysis of the data has supported the development of improved tools, technologies and practices. This has in turn allowed very significant improvement of the production of dairy cows. In aquaculture, we do things the other way around," said Dominique.

"We develop the fish, the genetic or genomic technology without having proper data, proper benchmark, proper growth model, proper mathematical equation, and proper sharing of data. Everybody's working on his/her own. We need a more unified and standardised system where data are put together, and then we can develop more reliable predictions and reach more meaningful conclusions.

Early weaning with high performance larval feeds

"Development of microdiets for early life stages has been a priority in academic and industrial marine fish larval research since the 1990s. However, there continues to be challenges and difficulties," said **Dr Conceição**, CEO and R&D Director, SPAROS Lda, Portugal.

"Progress has been considerable, with good weaning results shown with commercial microdiets, for the European seabass and gilthead seabream in the Mediterranean and red seabream and olive flounder in Asia. The work still remains challenging for nutritionists and formulators but solutions are critical as early nutrition may affect utilization of on-growing diets," said Conceição.

"The fish larvae paradox is due to the immature digestive system but high growth rates (10-20%/day and up to 50%/day) which means high requirements in terms of amino acids, highly unsaturated fatty acids (HUFAs), phospholipids, vitamins and other nutrients; moreover these nutrients must be given to larvae in highly available forms, meaning high quality ingredients."

Inert microdiets

The main challenges with inert microdiets are that they tend to be poorly digestible when compared to live feeds. These have resulted in low predictability in survival, sub-optimal growth (larvae and juveniles) and quality problems (deformities). "In the last 20 years, there has been progress with inclusion of protein hydrolysates, information on requirements on HUFAs and phospholipids, and on feed processing technology. However, we still see that *Artemia* replacement is making slow progress at many seabass and seabream hatcheries such as those in the Mediterranean, is largely because of the risk perception by hatchery managers and the fear of an increase in skeletal deformities."

There are biological and technological constraints toward the development of effective microdiets. "Even if we have a reasonable understanding of what fish larvae roughly require in their diets and sources of micronutrients, the exact nutritional requirements are still poorly understood. Then we must look at nutrients leaching in inert microdiets, due to the small particle sizes. We need improved technology and formulations for high performance diets."

"A major constraint is that we cannot measure easily the efficacy of diets because of the small size of the animals. Most species do not perform well on inert diets; assessing food intake and digestibility of diets is a major challenge and dose-response studies are very difficult to perform," added Luís.

A good microdiet for fish larvae needs to meet some specifications, such as:

- nutritional adequacy to the requirements of the target species;
- a technological production process that promotes ingestion, allows easy digestion, prevents nutrient loss to the surrounding water by leaching and disaggregation; and
- optimal physical properties such as floatability, sinking speed, dispersion both in the tank surface and water column to ensure a higher ingestion by fish larvae.

Nutrient requirements of larvae

"When we look at the amino acid profiles of larvae and try to match with live feeds, we see some imbalances. Dietary amino acids have functions besides growth; these include energy production or their conversion to lipid, hormones, enzymes, purines and pyrimidines and cofactors. A diet with a balanced amino acid profile reduced incidence of skeletal deformities in white seabream.

"Fatty acids are required for growth and energy but also critical for larval quality and pigmentation. HUFAs such as docosahexanenoic acid (DHA 22:6n-3), eicosapentaenoic acid (EPA 20:5n-3) and arachidonic acid (ARA 20:4n-6) are most important. Phospholipids also play a role in stress resistance and skeletal development. However what are the dietary requirements, and optimal ratios? and can we find sources (raw materials) at reasonable prices?" asked Luís.

Conceição showed results of studies where the meagre and seabream required high protein and high energy diets (64% protein; 22% lipid) and in contrast, the Senegalese sole, performs better on moderate dietary lipid levels (14%) and a high DHA/EPA ratio. In the case of phospholipid sources, seabream survival was higher with krill meal than with soybean lecithin.

Diets must be highly digestible with bioavailable ingredients as well as low leaching levels. Too much leaching will affect water quality. Microencapsulation can reduce nutrient leaching but this may affect digestibility, so a balance between these two factors is required. "Cost-effective technological solutions are needed.

Does one larval feed fit all?

The optimal diet changes with fish species, size and environment. "It has been shown that sole larvae perform very well with a diet based on a mix of vegetable and marine ingredients." Interestingly, when this same microdiet was used on gilthead seabream larvae results were not as positive: a lower growth was observed compared to other microdiets. Seabream larvae perform better on a diet based on squid meal.

"While most commercial microdiets available were developed in Europe and Japan targeting slower growing species, we know that fast growing fish larvae such as the amberjack/yellowtail, have exceptional requirements for protein and other nutrients. A prototype feed for *Seriola dumerili* is 62% crude protein: 18% crude fat. Compared to a commercial diet, the feed conversion ratio (FCR) was 13% better with the fast performance prototype diet. Weaning was achieved at 34 days compared to 42 days when fed a high quality commercial diet."

Early co-feeding promotes growth in the long-term; in sole it was shown to be advantageous to use a co-feeding regime from the time of mouth opening, as even if growth is initially somewhat reduced, it results in the production of larger and better-quality post larvae at the later development stages.

Live feed replacement will increasingly be a reality, leading to many species feeding exclusively (or almost) on high quality inert microdiets "While in 2010, for the Senegalese sole, a full weaning was only achieved at 40-DAH, in 2016, it was possible to achieve full weaning at 25-DAH with survival of over 90% and growth rates above 10%/day."

Luís' message was, "Some species may require specific diets, or may perform well on cheaper diets. However, diets must be selected on cost-effectiveness and not on price."

New tendencies and challenges in aqua feed formulation

As aqua feed manufacturers work at replacing fish meal with plant meals, **Muccio**, BIOMIN Holding GmbH, Austria, said that alongside this trend, issues with mycotoxins will rise.

"Although plant meals are cheaper and contain valuable nutrients that can benefit production, some nutrients are less accessible requiring higher inclusion rates. Nutrient optimization is needed perhaps with enzymes, acidifiers, yeast, fungi, bacteria, genetic manipulation, and supplementation with feed additives, probiotics, prebiotics, synbiotics and nucleotides. There are also possibilities of bacterial and fungal contamination and the presence of antinutritional factors such as mycotoxins."

Focusing on mycotoxins

In his presentation, Michele introduced the different types of mycotoxins which produce toxic fungal metabolites with a broad range of severe negative effects on performances. These infect all kinds of commodities worldwide. According to FAO, at least 25% of the world's crops are contaminated by mycotoxins. Some mycotoxin-producing fungi, such as *Fusarium* mainly grow in the field, while others, such as *Aspergillus*, are mainly found under adverse storage conditions.

"Mycotoxins present an emerging issue in aquaculture with the increasing tendency to include higher ratios of plant-based ingredients in aqua feeds. As far as agriculture is concerned, we have 400 different mycotoxins in various commodities," said Michele.

The effects of mycotoxins in aquatic species are documented in the literature. These depend on the type of toxins, species, and among environmental factors. Effects also depend on the mycotoxin concentration, as well as duration of exposure, the nutritional status of the animal as well as the inclusion rates of plant meals in fish feeds. Some of the effects with aflatoxin (AF) contamination include vacuolar degeneration, histopathological changes, decreased feed conversion ratios and growth rate in the tilapia. In catfish, histopathological changes and stomach necrosis after 10 weeks was reported with 10,000 ppb AF. In carp, a strong immunosuppression was reported with 350-1000 ppb of deoxynivalenol (DON) contamination. Growth and average weight gain of tilapia fingerlings were affected by 10,000 ppb of fumonisins (FB)."

Some maximum values for the main mycotoxins contaminating Asian samples of plant meals from a survey conducted in 2016 were given. "Soybean meal, widely used at more than 40% in fish feeds, had a low contamination level but wheat meal, used at 20-25% levels in low trophic species and 10-20% in feeds for higher trophic species showed contamination levels of more than 6,900 ppb of DON."

He added that although corn and corn meal is used at low levels, from 10-40%, FB contamination reached maximum levels of more than 16,000 ppb. Corn gluten meal, used at less than 10% in feeds for high trophic level fish registered DON at 11,518 ppb. Rapeseed and canola meal, usually included at 40% in carp feeds and only 5% in salmonid feeds, had low contamination levels with DON at 2,431 ppb while cottonseed meal, added at 25% in feeds for tilapia, was contaminated with AF at more than 9,000 ppb. Rice bran is popular in Asia as a supplemental feed for the pangasius and often included at 10-25% in tilapia feed, has relatively low contamination levels of 545 ppb of zearalenone.

The message is that, "Mycotoxins act as threats to aquaculture and even at a low dose they can depress the immune system and decrease performances."

A future with fish meal-free feeds

Dr Anant S Bharadwaj, Director of Nutrition, Integrated Aquaculture International (iAqua), USA discussed the challenges in developing fish meal-free feeds. In Asia, even the omnivores, mainly tilapia, carps and pangasius use fish meal: 2-3% fish meal in tilapia feeds, 0-30% in carp feeds (depending on life stages) and 3-10% in grow-out feeds for the pangasius.

"The push for aqua feed producers to replace fish meal with perhaps plant meals and other alternatives is because of price increases and limited supplies. There are interests as well as critical needs among feed producers to reduce fish meal or to produce fish meal-free feeds that promote similar growth performance at lower costs. It is, however, interesting that studies show that the pangasius can grow without fish meal but fish meal is still used," said Anant. Another push factor is from the retailers and consumers, wanting to promote fish fed feeds that contain no marine proteins.

"In Asia, although nutritionally balanced mixtures of plant and terrestrial animal protein sources promote growth in marine species that are similar to that seen in fish fed fish meal based feeds, both feed producers and users seem reluctant to eliminate fish meal or reduce use to very low levels."

Fish meal is a complex ingredient and replacing it requires combinations of quality ingredients to meet the nutrient requirements of the target species. Only more recently, are such ingredients and supplements more available and less expensive, making fish meal-free feeds a distinct possibility.

According to Anant, studies on numerous species showed that replacement of fish meal with high inclusion levels of alternate proteins have resulted in growth depression. "These were because of reduced or poor palatability, reduced feed intake, nutrient deficiencies and compromised gut integrity. In addition, the lack of detailed information on nutrient requirements of target species, composition of ingredients and nutrient digestibility of ingredients has also hampered efforts."

Precision formulations

There has been progress with developing low fish meal or fish meal-free feeds for some Asian fish species, such as tilapia, catfish and carp species using poultry meal without affecting growth performance. Similarly, this was observed in tiger grouper fed reduced fish meal which was replaced with soybean meals. However, in feeds for the Asian seabass, feed intake decreased with reductions in fish meal.

Some consequences of replacement of fish meal include enteritis of gut when fed elevated levels of soybean meal in the carp, and decreased gut enzyme activity in the gibel carp. In the tilapia, there have been minor disruption in intestinal histology and increase in goblet cells but the fish were able to adapt. In the orange spotted grouper, there was intestinal damage. The question is: would feed supplements help?

There were also indications of strain dependent differences in the degree of sensitivity to high dietary soybean meal in the rainbow trout. A genetic variation in utilisation of plant proteins was seen with a strain developed for improved utilisation. Family based difference in response to plant protein was observed in the European seabass. "Does this mean that strains with higher tolerance to some plant meals should be developed?" asked Anant.

His message was, "Despite many alternative protein and lipid sources and feed supplements increasingly available at lower prices, there are still numerous challenges to overcome to develop fish meal-free feeds on a wider scale, in particular for the marine fish.

Benchmarking: The Salmon Model

Dr Bent Pedersen, Global Category Manager – Aquaculture, DSM Nutritional Products, Denmark, discussed some developments in salmon farming, highlighting the various subjects and technologies from the salmon industry of direct relevance and inspiration for warm water aquaculture in Asia.

"There will be areas of common interest like sustainability which is getting increasingly important also in Asia. As more people enter the middle class, consumers become more demanding on quality and food safety. A lot of the things we have been through on the salmon side will also be important here in Asia. We may not be able to cut and paste, but some experiences from one place can be applied in another. We can modulate it into a different picture in a different area because standards, cultures, and consumer preferences may be different."

Asia already accounts for 89% of global farmed seafood supply and of this 63% is produced in China. While Asia is expected to realize the highest growth in consumption of seafood, profitable growth within the aquaculture sector is essential.

Years back in the salmon industry, we all talked about producing salmon. However, throughout the years, markets and the industry matured and topics like sustainable and ethical production, food safety and consumer preference grew in importance and are now essential factors defining the future growth of the salmon industry.

Future considerations for the industry according to Pedersen are to expand production of aquaculture especially by intensification, i.e. to increase yields through advances in farming technology.

"This implies to further develop feeds in terms of quality, use of ingredients, cost/efficacy, and health management but also to grow the industry in Asia with a view to ethical production and the environment. The future of fish farming in Asia will not be just about production."

In his description on developments and characteristics of the Atlantic salmon industry, Pedersen said it is expected to grow 40-60% by 2030. More importantly, it is research driven development, with regard to nutrition, feed ingredients, genetics, health, etc.

Extruded feed soon became the standard for the industry. Based on years of intensive research, feed composition gradually changed from fish meal/fish oil based to low level fish meal/fish oil plus a diversified blend of plant ingredients. FCR is 1:1.2. Farming here uses intensive production systems, with fish density regulated by law. Automated feeding and monitoring systems control each cage in various locations. One important trend is to produce in a sustainable way. New licenses in Norway are dependent on proof of sustainable production.

In Norway salmon farming happens virtually without the use of antibiotics but the health status of salmon is supported by vaccination and immune stimulation through functional feeds. "The overall success is a result of cooperation and joint efforts throughout the industry, between authorities, research, the industry and marketing," said Pedersen.

The new normal

"For cost and sustainability reasons, fish meal is progressively being replaced by plant meals. While in 1990 fish meal counted for 65%, this has been reduced to less than 18% in 2013.

Plant ingredients are being increasingly used in farmed fish diets; but what does this mean for the nutritional value of the diet? E.g. Norwegian researchers have recently looked at whether the levels of B-vitamins added to the feed need to be adjusted when plant ingredients are used in the diet of Atlantic salmon.

"The improved FCR in Norway has reduced the relative feed requirements by about 170,000 tonnes over five years (2009 to 2014). The strategy is not only lowering FCR but also levelling out big fluctuations in feed production/feed ingredients requirement throughout the year. "

The future is also health and biology. Sea lice is being researched intensively to find suitable ways to avoid chemical treatment of the fish and new functional feeds are constantly being developed in order to support e.g. immune functionality.

Of all stakeholders, consumers have the strongest impact on how fish is produced in future. Our role is to work on how to communicate to the consumer. It is important that we explain to the consumer in a correct way how we produce the fish, etc. The middle-class consumers will continue to rise and be decisive for our permission to grow."

Kill the killers or live with them- How to be successful in tropical fish farming'

In the final presentation at the plenary of TARS 2017, **Alain Michel**, Consultant, France recounted his 16- year foray into setting up an Asian seabass *Lates calcarifer* or barramundi cage culture farm in Indonesia and open a new road for success in the farming of tropical marine fish. His presentation included the farm's battle against several viral, bacterial and parasitic diseases over that period. The final outcome was the discovery of the non-lethal heat shock treatment for controlling diseases.

This presentation was published as two articles in Aqua Culture Asia Pacific. In issue May/June 2017, Michel discussed disease control in aquaculture, and the path developed to live with pathogens. In issue September/October 2017, Michel discussed farming the barramundi alongside pathogens, and learning the hard way at an integrated farm in Indonesia.

At TARS, Michel had the following messages:
Why develop more finfish farming in Asia? "There is a large demand in local and world markets for various finfish such as barramundi, snappers, groupers, pomfret, cobia or even saline tilapia cultured in offshore sea cages. We have the technology and husbandry knowledge to develop a tropical model to compete with the salmon and fulfil the high demands of the frozen fillet on the world market.

On the new direction, Michel said, "Disease is a constant threat. Current production based on the biosecurity concept which relies on pathogen exclusion, is a 'mission impossible'. The new paradigm is living with pathogens as partners. This is boosting the fish immune system through non-lethal thermal shocks. The underlying mechanism is the upregulation of the heat shock protein. It is an innovative approach of vaccination in 'live strengthening' of the juveniles at the nursery step through contact with the pathogen of the surrounding environment to prepare fish for transfer to sea cages.

"We can control various viruses, bacteria and parasites in this way without fearing viral mutation or different bacteria serotypes. Well trained and dedicated technicians can easily use this new tool at the commercial level and forget antibiotics. For barramundi and tilapia, survival can reach 80% dealing with viral nervous necrosis, different iridovirus, scale drop and big belly bacteria as well as *Flexibacter*."

Hard Talk with finfish farmers

The panel comprised (from left) Amorn Luengnaruemitchai, I Gusti Arya Ameri Eman Himawan and Tan Kay Heok

Reflecting the range of finfish species farmed in Asia, this year's Hard Talk segment invited two farmers from the marine finfish sector; a CEO operating a barramundi (Asian seabass *Lates calcarifer*) farm in Indonesia and a CTO operating a Asian seabass and fourfinger threadfin (*Eleutheronema tetradactylum*) farm in Singapore. Joining them was the MD of a major tilapia hatchery company in Thailand.

The panel **I Gusti Arya Ameri Eman Himawan** is CEO and Owner of PT Bali Barramundi, a fully integrated aquaculture company, set up in 2012 in Gerokgak, West Bali. The company has a land-based hatchery and nursery with cages offshore. It also runs a seafood restaurant in Denpasar. It is one of the top 4 marine finfish farming businesses in Indonesia.

Tan Kay Heok is Chief Technical Officer at Marine Life Aquaculture Pte Ltd (MLA) in Singapore. MLA has a hatchery, nursery and grow-out business mainly of the seabass and fourfinger threadfin. Tan Kay Heok, manages all technical aspects related to land-based and net cage divisions at MLA.

Amorn Luengnaruemitchai is Managing Director of Manit Farm Co. Ltd, a hatchery business in Thailand. Amorn also established the Manit Farm's Breeding Nucleus Center for Nile and red tilapia.

The farms

PT Bali Barramundi uses a three-phase farming system for the barramundi. The hatchery's capacity is 100,000 fingerlings/month in an indoor land-based hatchery, while the 80-day nursery stage produces up to 30,000 fingerlings/month in tanks and cages. The farm starts harvesting with 500 g with regular partial harvest from 1.0 kg up to 2.5 kg for every cage.

Marine Life Aquaculture Pte Ltd (MLA) has a three-phase system, from land based hatchery and nursery facilities to grow out in cages. There is a 60-day nursery stage for the fourfinger threadfin. MLA's grow-out cage farm area has a total culture volume of 20,000 m^2. The farm's special features include, vaccinations with Strep-Si and Irido-V, stand-by pure oxygen and canvas bags for red tide.

Manit Farm has three hatcheries and nursery facilities in Phetchaburi, Thailand, covering a total 320 ha producing 0.3-1.0g fry and 20-50g fingerlings. The total output/year is over 200 million fry. Some of the farm's special features are vaccination of broodstock, probiotics for water treatment and feed probiotics. The Nile and red tilapia fry and fingerlings were the major species in 2016.

On challenges and lessons learnt

Amorn: We were better because we diversified into tilapia, giving a steady source of income for the company. Later on, we started to distribute the feed and sell other products. If we did not do this, I am quite sure that we will not exist today.

Eman: I strongly believe in the traditional philosophy of life on the island of Bali: *Tri Hita Karana*, emphasising 'harmony with the people, nature and god'. Fish farming is very challenging and it costs a lot of money. I started this business because I was finding it so difficult to get supplies of barramundi, although I already have a market in Australia. Now my farm can supply 50% of demand. In terms of production, the most difficult thing in the past 4 years is getting good quality fingerlings derived from high quality and genetically improved broodstock".

Kay Heok: We have learnt the professionalism in the salmon industry. There, the vaccination team is different from the anaesthetic team. What we learnt from them is that we can knock out the fish, but not to overdo it or else fish will not recover. I advise you not to be wary of vaccination. "Once the protocol is set, vaccination is easy.

On mitigating fish mortality

Amorn: Survival rates are already high at 90%. The room to improve is small, but improvements are still possible. Tilapia is a robust fish. If we have a problem with disease, we find the hapa dirty or the pond is not well treated. *Streptococcus* is always dominant in Thailand when the temperature is above 33-34°C. To mitigate mortality, genetic improvement is key and is one where we can clearly see the improvement. Vaccination is very promising as well. Of course, management is important.

Eman: At PT Bali Barramundi's hatchery, larvae survival rate up to 2-10 cm fry is very low at 15%. It is 50% for juveniles from 10 cm to 200 g. Survival of larger fish (>200 g) in cages can reach 70%. When the weather is good, we stock the cages with 3.5 cm fry rather than keep in the nursery. If we stock 200 fish, we will get 100 fish. If the farm vaccinates the fish, the result is 10% higher with the survival rate of 60%". However, to have a better business, the farm needs to have at least 70% survival rate. We need good broodstock to improve the survival rate.

Kay Heok: At MLA, the survival rate of fourfinger threadfin larvae is around 30–40% with early weaning at day 8. After day 15 in the nursery, the survival rate goes up to 80%. At 20 g, fingerlings are

vaccinated with intraperitoneal (IP) injections. Usually, mortality of the fourfinger threadfin is attributed to mishandling as scales are small. To solve this problem, the farm uses a fish pump, an auto grader modified with shower, and an auto counter. Post vaccination loss is only 10-20% for the threadfin and lower at 1% for the seabass. Transfers over >700 m to cages with a pump only result in a 1% loss. The investment is worthwhile as the machines last more than 10 years.

MLA has their SOP for disease prevention. Firstly, grading will cull out all the undersized fish because smaller fish have under-developed swim bladders and are disease carriers. A second approach is to upregulate stress tolerance with heat shock protein (hsp) treatment prior to vaccination and then cull out weak fish. This is done in the first 7 days when viral nervous necrosis (VNN) infections are high. But prior to this process, Tan Kay Heok advised to monitor hourly the frequency of rotifer feeding as larvae reach the open mouth stages. You can save a lot of fish, by not waiting until the disease outbreak before applying hsp. This is a good disease prevention tool.

On weakest links in supply chain

Each farmer gave his views on where he thought was the weakest link in the supply chain and what help will be required.

Marketing, image and branding

Amorn: The marketing of tilapia in Thailand is very weak. Nobody in Thailand takes care of the image aspect. The focus is on farming and production. We do not have the equivalent as in the marketing of the salmon in Norway Look at how well Norway promoted the salmon all over the world.

Eman: The weak link is image and branding for the barramundi. Even the locals in Indonesia are not familiar with the barramundi. That is why we mention barramundi from Bali is farmed in sea cages so that the image is good. Sea-cage barramundi is sold at a higher price.

Genetic selection

Genetic selection is one area where producers will need the support from governments.

Eman: On genetics, we hope to have support from the government to improve brood stock quality.

Kay Heok: In order to imrove production, MLA needs to carry out its own genetic selection program. However, broodstock fish need biosecure facilities and require a land absed faciility to ensure good quality eggs.

TARS 2017: Report on Breakout Roundtable Sessions

Strategies for Growth via Production, Efficiency & Industrialisation; Marketing, Image & Sustainability; Performance & Functional Feeds

Production, Efficiency & Industrialisation

For **efficiency in production**, participants expressed doubts on whether small and large feedmills produce well-balanced nutritional feeds. Farmers still focus on price/kg of feed rather than on quality, growth performance and feed conversion ratio. In the farmer-feedmiller relationship, ultimately the lowest cost feed wins. For the industry to survive, this 'has to be broken' because feedmills need resources to invest in developing diets, to give farmers a better performance feed. If a feed company has to be of a certain size, farmers need to accept that it costs money to invest. Otherwise, the industry would never get out of this trap of getting cheap feed. It was reiterated that the lowest cost has nothing to do with least cost formulation.

Improving feed quality at a reasonable price is one of the most important targets. Higher feed quality is needed for more efficient, well-controlled and documented feed usage based on research. Moving to dry feed, away from wet feed and trash feed is key and this is the trend in Asia. Relevant feed additives such as phytase,will liberate phosphorus and the use of dietary phosphorus, thereby reducing excretion of phosphorus into the environment.

The general lack of **vaccines for several important diseases** is a main problem. Certain vaccines against certain diseases as well as nutritional immune stimulation concepts are available, and can be used in the same way as for cold-water aquaculture. Vaccines are usually developed for the main diseases only - this is a constraint in Asia where production for a large number of species; thus, multispecies farming is a future constraint. Another constraint is that farmers do not keep track of diseases and mortality.

With **disease mitigation**, small-scale farmers usually opt for the one with the least cost. They need proper introduction and exposure to new production systems and vaccination techniques before incorporating vaccination into their farming protocols. Understanding biosecurity and prevention for disease prevention is critical. An absence of biosecurity systems means difficulties with disease management.

In terms of **vaccines**, the setbacks identified were: registration of the vaccines in each country, farmer acceptance on vaccination, and roadblock to training the workforce to properly vaccinate the fish. The process for registration of vaccines such as in Vietnam was discussed. While the vaccine is available in many other countries, in Vietnam, the registration on Strep-Si took more than three years and with a stipulation to conduct field trials over a complete production cycle.

The traditional mindset, for example of Malaysian farmers on the high cost of vaccines/fish encourages the stocking a lot of fish allocating for high mortality. Farmers see a 10% improvement in survival as this is small at the nursery phase. However, 10% higher survival seen, for example, at day 200 of the culture period, is very important when considering the return on investment for vaccines. In Asia, it takes a long time, both for vaccine development, marketing, and also, the acceptability of the farmer, particularly small-scale farmers.

In training the workforce on how to vaccinate fish, the group noted that a large farm in Vietnam organised local women to carry out the injection process (8,000 fish/day). They became the "on call" vaccination team for the farm. In Vietnam, vaccine provider had a professional team of 40 staff to carry out vaccinations against the Ictaluri bacteria in the pangasius, After two weeks, mortality is evaluated and vaccine payments made. On the need for antibiotics prior to vaccination, this can be replaced by heat shock treatment as applied at the MLA farm in Singapore.

Large-scale operations are already using **technologies** common in various parts of aquaculture, but also in other industries. For small-scale operations, simplified systems can significantly improve farm operations like automatic feeders, transporters. For

these operations, it is not about pouring huge investments into sophisticated machinery but about bits and pieces, which if done step-by-step, could improve productivity. Among the weaknesses are handling and maintenance; the latter should definitely not be underestimated. In many industries, maintenance is a problem. The availability of power sources for small-scale operations seems to be a widespread issue throughout aquaculture in Asia.

Knowledge sharing, operational awareness, and education on interrelationships between the various aquaculture disciplines were emphasized as part of training.

While integration is more relevant to larger companies, segmentation works better for smaller operations, which also requires support from local government, and some form of specialisation. Whether there is **integration or segmentation**, this depends on the local reality in terms of finance, traditions, and business opportunities. The way forward is to develop integration in line with business opportunities and financing. Group members unanimously agreed on the demand for more education and development with regards to farm management and environmental issues.

Marketing, Image & Sustainability

The whole aquaculture industry is struggling with a **perception issue** when it comes to **product image** at the farm and country levels, As a new industry, aquaculture has received more attention. The media also prefers to report on negative stories rather thanpositive ones. Industry-wise, this is a weakness and more effort is needs to encourage and publicise good stories.

In general, seafood is generally recognised for its health benefits Aquaculture is also recognized for its positiveimpact on economic production, jobs, and business opportunities. A way forward to influence the negative perception on the industry is by 'interaction' and to talk as an industry', not as individual players via industry associations such as cooperatives.

The industry, as a whole, needs to move fast to address to any **negative news**. In Vietnam, a positive development was a response within 5 months to the Spanish Channel 4 documentary that depicted the negative image of the pangasius. Stakeholders also need to determine the bad apples in the industry. One bad apple is a failure industry-wise. There is frequent news on rejected containers. Consumers do not identify with any specific company but the country of origin.

The industry could use a more systematic monitoring of consumers' perception. Lessons from the salmon industry showed that some of those promotions have really changed perception among consumers when measured over time. One tangible measure is increase in sales volumes. Another option is documenting the economic impact in a community including number of jobs created, getting local suppliers, etc.

The weakness with **price elasticity** is that if fish becomes too expensive, it is then substituted with other food. Selling fish is complicated as premium prices are for fresh fish. Reducing price elasticity comes by moving away from the traditional way of selling the whole fish, i.e. increase the proportion of prepared convenience foods that has more flexibility in storage and distribution.

Ideally, the target is a better supply-demand balance but supply-demand for many white fish is quite difficult. Prices are influenced by many species. The many species makes mapping white fish difficult to control and measure. For example, to manage tilapia supply by country, an industry overview and annual tilapia production data are required.

As a consumer generation, **millennials** signal what the future is going to be like. They are more conscious of food origin and background, and are super technology savvy, -constantly engaging on social media and other technology platforms. As such, they are easily influenced and affected by the negative stories they read online. Producers need to keep up – they need to use social media effectively and have real time awareness of the impact on the industry. Furthermore, are they doing what is being asked, how the is the fish produced and what is the history behind it? The future of food distribution will be through e-commerce. Seafood producers need to monitor this aspect closely to ensure the right messages get out.

Environmental Conservation

Fish meal -free feed challenge is also part of the image of aquaculture. A zero-fish meal is not a target but resources that impact future fishing should not be used. Non-food grade marine ingredients should come from fisheries that are managed well. The industry has been slow to come up with the right substitutes. The way forward is to continue with the search for substitutes, and to to label and classify them as sustainable.

In resource and **environmental conservation**, the limitation is water; in particular, freshwater and aquaculture competes for the use of fresh water. In seawater, there are conflicts with other users - fisherman, tourism and sea transport. There is a history of pollution in water resources. The industry can definitely improve nutrient utilisation with better feeds and improve farm practices. Ultimately, to be sustainable in the future, it is moving to closed systems or ways of using less water.

Case study: Indonesia's finfish farming industry

The group did a case study and mapped out general challenges to Indonesia's finfish farming industry. There is a tradition of seafood consumption and there are premium markets and prices where origin, quality and price are in place, including certifications. The weaknesses include regulations that are limiting and are not sufficiently targeted. The different types of farmers with different interest and different capabilities are issues when addressing industry-like challenges. The proposal was for stakeholders in the entire value chain to work together on the regulatory framework, political and environmental issues. This could be facilitated via a roundtable conference with the attendance of significant stakeholders. The aim is to address issues as an industry to help both local farmers and allow the potential to grow. This is also open to famers who do export but may be interested in some of the shared topics selected so as to present a concerted approach to governments to seek a viable solutions for all concerned.

PE investment in aquaculture

Financing was discussed and what it would take for private equity (PE) firms to invest more in aquaculture projects. One drawback for aquaculture is volatility and extreme capital intensive. Often, PE money is timed, i.e. there is a certain length of time for funds. But actually, the negative image comes from the volatility at the farm level. Volatility in the farming segment for aquaculture worries PE Money.

However, Asian PE money is more attracted when projects have integration including farming. Once the farming side is integrated with a genetic source, hatchery, nursery or even some feedmill or downstream, it captures the value and accentuates quite a lot of the cyclicality. Additionally, farms/people with good ideas and integration aspirations with innovative, forward-thinking manager attract PE funding.

Bergen-based Triton established a seafood investment fund that targets consumers or savings investment and is 70% Asian focused. The fund searches for the same things as consumers. It needs information and transparency because every investor needs to know what they are investing in. So, both from a financial

perspective, there is access to the financial information, but also to the industry information. This means that if such investors want to invest into pangasius, tilapia or shrimp, they need to have insights on the biology and risks associated to the investments. Thus, if the industry wants to attract capital it needs to take that side because that's how capital works. Seafood is attractive and is for the future and the Triton fund considers the long-term perspective of the aquaculture when they are describing the outlook, and that includes Asian aquaculture. Oslo's stock exchange has 10 listed aquaculture companies - all of them in aquaculture. The first one was listed in 2003 when the salmon industry was still immature. The great thing about these listings is that they have been developed around a group of analysts. The synergy was that the financial analysts give feedback and analyses to the industry. The salmon industry is more mature but still has the risk element but it has developed sufficient information to attract investors.

Performance & Functional Feeds

Feeds with different nutrient densities are required for the **different life stages**, developing proper broodstock feeds and eliminating live feeds for broodstock. Farmers should have better information and understanding of nutritional requirements, especially since micronutrient requirement of fish changes with life stages, environments, temperatures, and stress conditions. There is a lack of knowledge in terms of precision nutrition.

The focus on **feed cost/kg fish** produced is one way of converting farmers from buying cheap feeds. The feed price is the cost side but there is an income side also, which is the gross rate times the value of the fish. In addition, there is the effect of fish quality; it can be the taste, the pigmentation etc. These three elements, the cost, income, and the quality of the fish have to be part of how the diet is formulated.

Performance feeds are relatively more expensive because of the better quality raw materials and balanced amino acids used for faster growth and lower loss of nutrients (pollution). The future direction for feedmills is to compete on performance and not on the low cost as it is done in most cases. Farmer and feedmiller education is important with regards to performance, and farms should use feed that is suitable for them.

Although the demand is for **functional feeds** and not just nutritional feeds, there are difficulties in understanding functional feeds, i,e. how important it is to apply and to use it judiciously and adequately. In Vietnam and Thailand, there are too many government requirements and constraints, limiting innovation. Feeds for biofloc systems and recirculating aquaculture systems (RAS) were suggested.

High pelleting temperatures might destroy some nutrients. There is a need for better ways to produce extruded feeds and move away from pelleted feeds. The need is also for attractants and palatants to improve feed intake. A strategy is to use functional feeds at the end of production, probably in the form of finishing feeds, but there is lack of attention to finisher feeds formulated by the smaller feedmills. These are usually very cheap feeds using poor quality raw materials. The opinion was that such feeds actually put a lot of stress at the final growing month, as at this stage, fish are much bigger. The market should dictate what kind of final feed it wants because that will be the final quality of fish.

There is lack of **species-specific feeds** and for different seasons for all of the species farmed in Asia. A survey on the composition of different feeds in the market, their various performances, and market analysis on feeds from different species needs to be done to try and understand the differences. An opinion was that if the demand is 30,000 -50,000 tonnes/year of feeds for a species, any knowledgeable feed miller should be able to fine-tune formulations and produce feeds specific for this species. Ultimately, more work needs to be done on species specific feeds for marine fish.

An counter idea proposed was to group species that have similar requirements. This means a focus on only 3-4 species or just 2 from freshwater species and 2 marine fish species. The group observed that tilapia and barramundi are already the top species, and probably more focus should be placed on them.

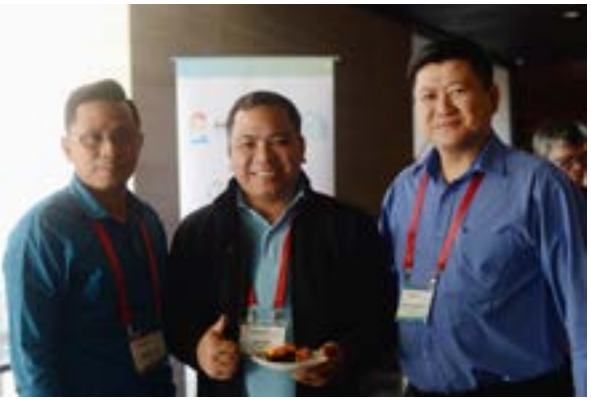
The group discussed feeds to address **health issues** and noted the need for facilities to carry out disease challenge trials to test these ingredients and additives. More work is needed with gut health. There are a large number of feed additives in the market, often with unknown interactions. It is important to benchmark these health additives and understand how they really work; otherwise producers may be less willing to alter feed practices and/or consider new additives and new ingredients.

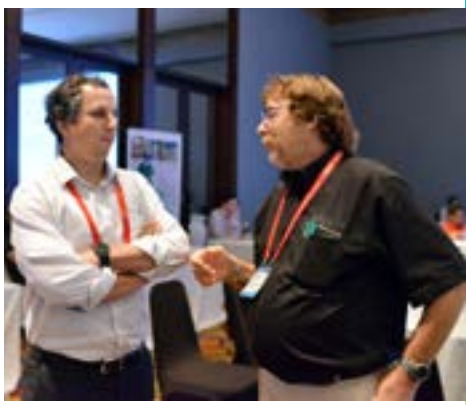
There is a need for robust data. In some countries, feed producers do not manage farms or have access to get robust data that would allow them to further progress with solutions. On sharing of very accurate data with feedmillers and farmers (in this case shrimp farmers) would give their worst case scenario as they are always negotiating on feed price. Farmers share feedback, not when something is going well but when they face problems. The feedback is not balanced and tend to be related to problems.

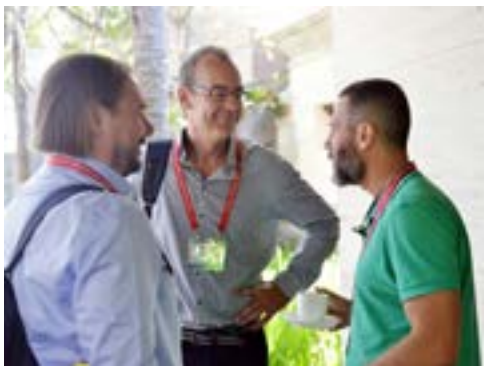
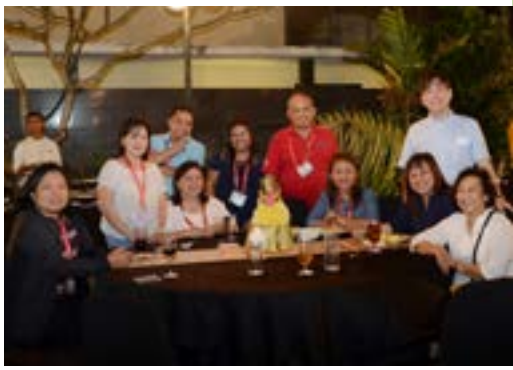
On feeds for fillet yield and fish quality, some issues on pigmentation arising from the inclusion of plant proteins were highlighted, and there were some concerns about no premiums for having feeds that promoted better fillet yields or better fillet quality because feed producers are not being paid for it.

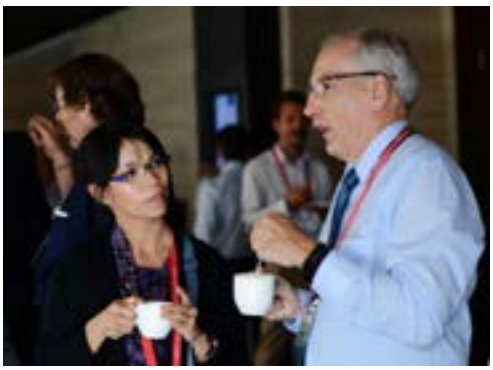
Throughout the session, the group stressed on the importance of **educating farmers and feedmillers** on good farming practices, nutrition, disease management. They also asked that government and the industry play a larger role, i.e. collaborate to streamline the industry, focus on a few species, and use them as models of future species. There is a need for advanced feed production technology and knowledge sharing. Seminars involving universities and training farmers by feedmillers would help them understand the nature of feeds and how these could be used.

More **transparency** between feed producers and farmers is required. There is more transparency in Europe, not because the mindset is different but that it is pushed by three factors: companies were forced to show transparency because they were bleeding money and government regulations require reporting on fish mortalities, escapes, contaminations, etc. These factors together with consumers forced feedmillers to be more transparent about what is in the diets, and as a result. Hence, no more black boxes at the farm level, feed level and country level.









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