SHRIMP INSIGHTS

SPF *L. vannamei* BROODSTOCK

***SHRIMP INSIGHTS* REPORT SERIES**

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CONTENT

LIST OF ABBREVIATIONS

ADG	Average daily gain
APE	All pathogens exposed
APHNS	Acute hepatopancreatic necrosis syndrome
BAP	Best Aquaculture Practices
BFAR	Bureau of Fisheries and Aquatic Resources
BMC	Broodstock multiplication center
BPS	Indonesia's statistics bureau
BPIU2K	Karangasem-Bali Superior Shrimp Broodstock Production Center
CAA	Coastal Aquaculture Authority
DOF	Department of Fisheries
EMS	Early mortality syndrome
F0 BROODSTOCK	Parent Broodstock
F1 BROODSTOCK	First generation Broodstock
F2 BROODSTOCK	Second generation Broodstock
HS CODE	Harmonised system code
IHHNV	Infectious hypodermal and hematopoietic necrosis virus
KKP	Ministry of Marine Affairs and Fisheries
MARD	Ministry of Agriculture and Rural Development
MPEDA	Marine Product Export Development Authority
NBC	Nucleus breeding center
MT	Metric ton
NAQUA	National Aquaculture Group
NOAA	National Oceanic and Atmospheric Administration
OIE	World Organisation for Animal Health, formerly the *Office International des Epizooties*
PL	Post-larvae
PPL	Parent post-larvae
RAS	Recirculating aquaculture system
RGCA	Rajiv Gandhi Centre for Aquaculture
SPF	Specific pathogen free
SPR	Specific pathogen resistant
SPT	Specific pathogen tolerant
TSV	Taura syndrome virus
USDA	United States Department of Agriculture
USMSFC	US Marine Shrimp Farming Consortium
WSSV	White spot syndrome virus

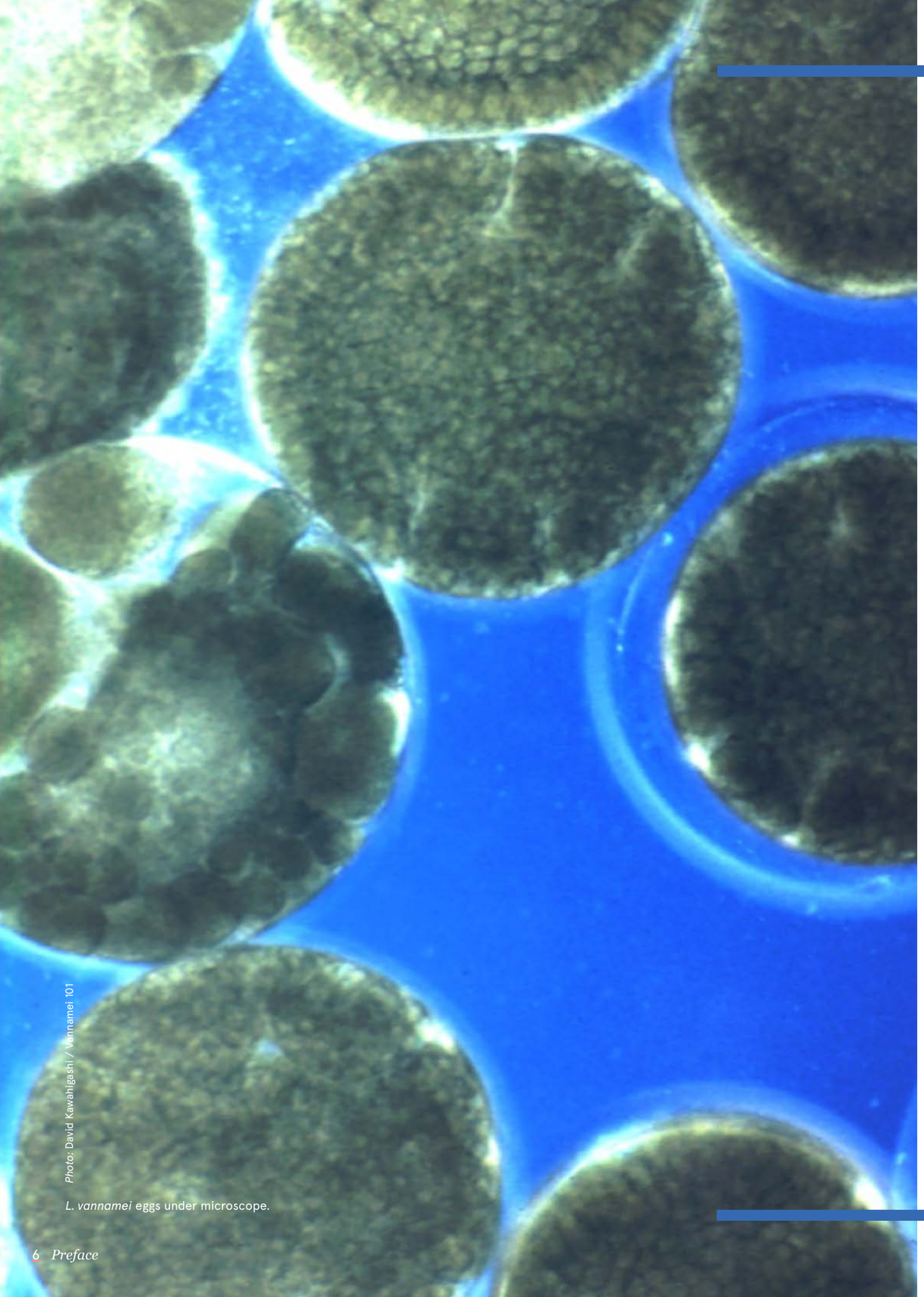


Photo: David Kawahigashi / Vannamei 101

L. vannamei eggs under microscope.

PREFACE

After several months of hard work, you are about to read the first publication of the *Shrimp Insights Report Series*, aimed at providing you with a deeper understanding of the shrimp industry. As I want these reports to be accessible for a broad audience – everyone benefits from more transparency in the industry – they can be downloaded for free at www.shrimpinsights.com.

Depending on how familiar you are with the sector already, after reading this first report you will have a better idea of trends in the production, trade, use and market of specific pathogen free (SPF) *L. vannamei* broodstock. Normally focusing more on downstream parts of the shrimp industry, broodstock was never really on my radar. However, when thinking about a research topic for my first publication, the choice for broodstock was quickly made. Broodstock being the beginning of the industry, it is fitting that it should be the start of this *Report Series* as well.

To put together this report I started studying existing publications and ran into articles written by broodstock pioneers like Jim Wyban, George Chamberlain and Robins McIntosh. I quickly realized that the broodstock business is extremely small and the people managing the genetics programs all know each other and many have even worked together at different stages of their careers. Conversations with some of these pioneers, especially with Jim Wyban and Robins McIntosh, gave me a clear impression of the current status and dynamics of the broodstock market.

The next step was creating an overview of available broodstock trade data. While some countries, such as India, Vietnam and the Philippines, publish detailed broodstock import data, other countries, such as China and Indonesia, do not make this data available. To get a grasp of the developments in those countries, I needed to use trade data and verify my calculations with local industry experts and broodstock company representatives. While sometimes challenging, I believe I have managed to provide a good overview of all major countries involved.

The last piece of the puzzle was the company survey which I conducted in January-July 2020. All fifteen companies covered in this report received draft company profiles containing publicly available information. Thirteen out of fifteen companies responded to my request for information, and their representatives helped to validate, complete and improve the information I had compiled. As the other two companies did not reply to my request or declined to provide further information, I have relied entirely on publicly available information for these profiles.

To engage with all the people in this segment of the industry was truly a pleasure. As a cultural anthropologist I am fascinated by how people from different backgrounds perceive their position in the industry. I am extremely grateful for having heard all those different perspectives and to collect them in a report which pays respect to all the individual views. I want to thank everyone who took the time to talk – without you, this report would not have been made!

KEY OBSERVATIONS

- In 2019, the size of the global market for specific pathogen free (SPF) *L. vannamei* broodstock is estimated to be between 1.4 and 1.7 million broodstock. With an average value of $55 per animal traded in 2019, this equals a value of $77m to $95m.

- The market for SPF *L. vannamei* broodstock is concentrated in Asia, especially in China, India, Indonesia, Thailand and Vietnam. Smaller markets are Malaysia, the Philippines, South Korea, Sri Lanka and Taiwan. South and Central American shrimp producers, including Ecuador, generally do not use SPF *L. vannamei* broodstock due to local production systems not always being biosecure. However, others, like Brazil, Mexico and Guatemala, might be potential markets for SPF *L. vannamei* broodstock in the future.

- Production of SPF *L. vannamei* broodstock in the US is concentrated in Florida, Texas and Hawaii, together producing two thirds of global SPF *L. vannamei* broodstock. Florida's contribution to total US exports has been increasing at the cost of Hawaii's share. In Asia, production is currently still largely accounted for by producers in Thailand, which produces both for the domestic and the export market. Other countries producing SPF *L. vannamei* broodstock are China, Indonesia, Mexico and Vietnam, but their contribution is marginal compared to producing giants Thailand and the US.

- The top five companies that produced SPF *L. vannamei* broodstock in 2019 are American Penaeid Inc. (API), Shrimp Improvement Systems (SIS), Kona Bay Shrimp (Kona Bay), CP Foods (CPF) and SyAqua. Whereas CPF produces only for its own hatcheries, the other four major producers sell on the open market. Combined, the top five producers account for 75% of total broodstock production. If Top Aquaculture Technologies, producing nearly as much as SyAqua, were to also be included, these six market leaders would account for 85% of total SPF *L. vannamei* broodstock production.

- Global demand for SPF *L. vannamei* broodstock is expected to increase alongside the expansion of shrimp farming in Asia and the Middle East. Our expectation is that a larger part of broodstock demand will be met by local production capacity. This would mean that international trade in broodstock might decline as overseas producers would supply parent broodstock or parent post-larvae to local broodstock multiplication centers (BMCs) which would produce the demand for more F1 broodstock, to be supplied to local hatcheries.

- Local breeding programs in Asia, other than those already established in Thailand, are expected to expand. Vietnam has one privately operated nucleus breeding center (NBC). Indonesia has one private and one government-operated NBC. India has recently approved the establishment of its first government-operated NBC. In China, multiple companies run their own breeding programs. Local breeding programs are often supported by governments as these believe that the local industry should not be overly dependent on imported broodstock.

- Several companies who run NBCs in the US and Mexico have local BMCs or hatcheries in Asia. The most prominent investments are the BMC of Blue Genetics in India, the hatcheries of SIS in India and the hatcheries of SyAqua in Indonesia. More BMCs and hatcheries are expected to be set up in the coming years. Companies that have publicly announced their ambition to set up BMCs or hatcheries in Asia include Hendrix Genetics and Benchmark Genetics Shrimp (Benchmark). Hendrix Genetics has invested in a breeding program and hatchery in Ecuador, runs its own NBC and BMC in Malaysia and has said that it is looking for similar opportunities in Asia. Likewise, Benchmark has started to build its first BMC in Thailand and is also looking at opportunities in other countries.

- Further consolidation in the breeding segment can be expected. In other animal protein sectors, genetics is often in the hands of only a few large players. Others use those breeding lines because the performance exceeds other breeding lines. For shrimp, the same will probably be the case. At this moment, large specialized players like Hendrix Genetics and Benchmark have just started their activities in shrimp genetics and have the capacity to expand. Although there is space for more players, the smaller independent but successful players such as API or SyAqua are likely potential targets for acquisition.

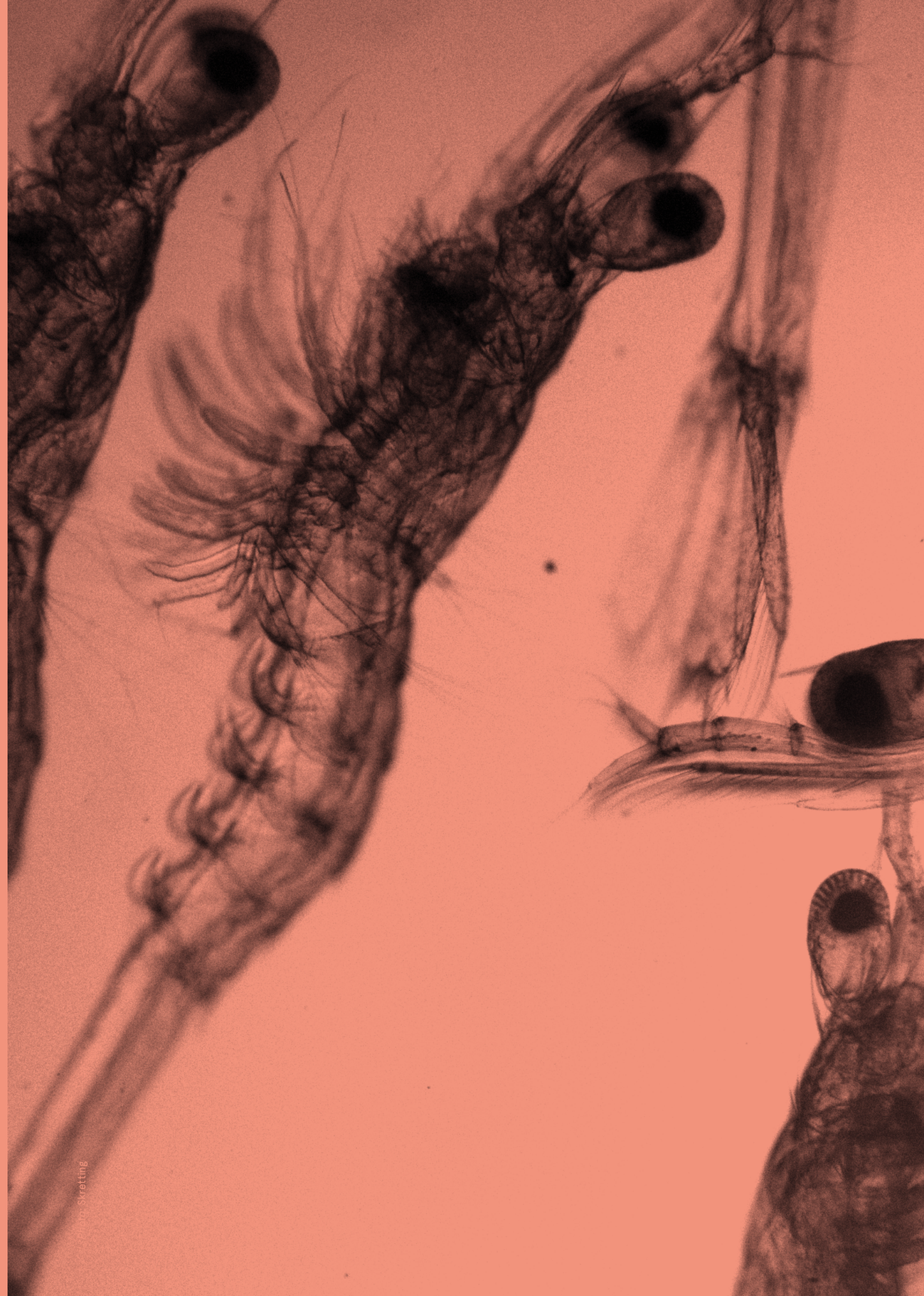
- In the hatchery segment of the main SPF *L. vannamei* broodstock markets, we also see more consolidation and integration taking place. Pure play hatchery companies are acquiring other hatcheries to grow and are moving into farming and processing to expand their reach. At the same time, processing companies and feed manufacturers are integrating hatcheries into their supply chains. While the hatchery segment in most countries is still fragmented, in the future there will likely be fewer but bigger SPF *L. vannamei* broodstock buyers.

- There is an increased focus among broodstock suppliers on disease tolerance. Many companies offer two lines to their clients, one focusing on growth, and another focusing on disease tolerance. Companies also increasingly offer other specialized lines such as broodstock that perform well in higher or lower densities, or that perform well in higher and lower salinity levels.

- Some of the broodstock suppliers have started to use more disease tolerant broodstock from South America to develop new SPF lines. Companies that have taken this approach include Primo Broodstock, North America Broodstock and API, which are currently working with animals from Ecuador, and Benchmark, which is using animals from Colombia. Other companies may follow soon.

- Covid-19 has had a severe impact on shrimp production and on shrimp broodstock logistics. However, once lockdowns were lifted, demand for broodstock in most Asian countries seems to have recovered quickly. India, for example, in June, was at par with its broodstock imports in 2019 and only 13% behind its broodstock imports in 2018. If the hatcheries were able to supply the farmers with post-larvae from these imported broodstock, a big crop of shrimp may be harvested until the end of the year.

L. vannamei nauplli under microscope.



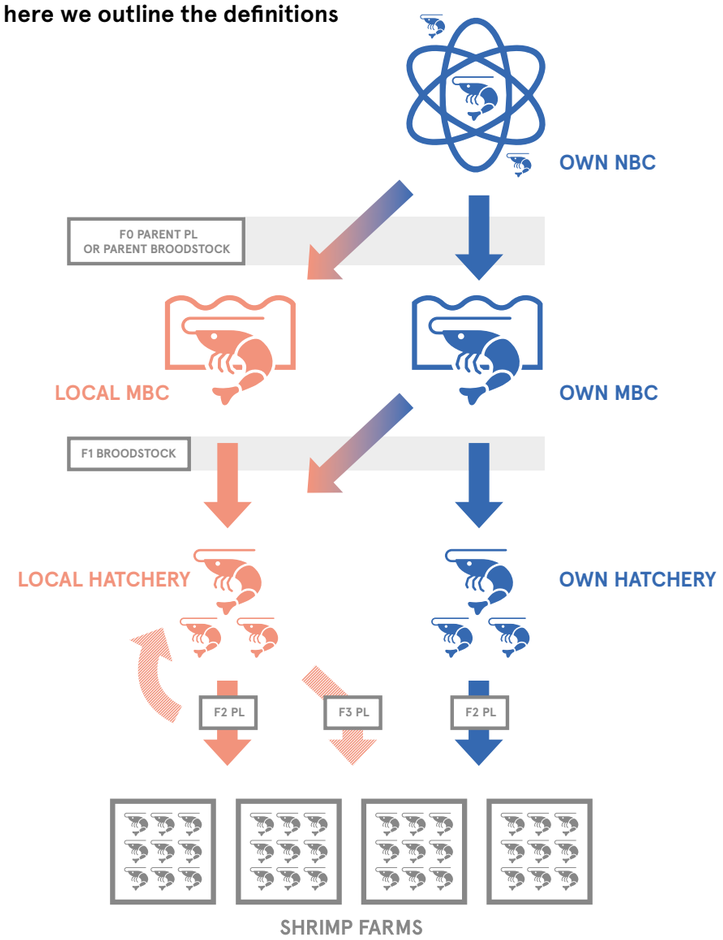
The Broodstock Supply Chain

Because different people use different definitions for the different generations (F) of broodstock and post-larvae (PL) that are used in the shrimp industry, here we outline the definitions used throughout this report.

This in-depth report addresses the part of the shrimp value chain from the nucleus breeding centers (NBCs) that produce parent post-larvae and parent broodstock (F0), all the way to the F1 broodstock that are supplied from broodstock multiplication centers (BMCs) to hatcheries. The hatcheries use this F1 broodstock to produce F2 PL to sell to farmers in their vicinity. The illustration on this page shows this supply chain and the flow of products between the different stages.

Although broodstock suppliers stress not to produce next generation broodstock from the F1 broodstock that they are supplied with, this nevertheless happens in almost every country. Some hatchery operators use F2 PL, the offspring of the F1 broodstock, to produce new broodstock which they will grow into F2 broodstock. The offspring of these F2 broodstock are labelled F3 PL.

The problem of using F3 PL is that the performance is often not as robust as the F2 PL due to the risks of inbreeding and because the specific pathogen free (SPF) status of these animals is often not maintained. F3 PL will likely grow less, vary more in size and is more prone to disease. While a hatchery might save cost by not having to buy new F1 broodstock, it causes risks for farmers as the PL these farmers buy might not perform optimally.



In recent years, in markets like Vietnam, Indonesia and in China, government authorities have been regulating the use of broodstock better. However, due to the fragmented nature of the hatchery sector in many of these countries, it's often difficult for farmers to control the origin of PL and broodstock.

This report focuses solely on the production, trade and use of F1 SPF *L. vannamei* broodstock.

Increase biosecurity through zero-water exchange protocol

www.inveaquaculture.com

One of the main risk factors in shrimp production, is disease through bacterial contamination. To reach the highest level of biosecurity, it is considered essential to control the entire production cycle with no entry of possibly contaminated water into the ponds. This is why INVE Aquaculture – part of Benchmark – ran extensive trials designed to introduce high density zero-water exchange protocols.

The main principle of INVE Aquaculture's zero-water exchange protocol is based on bacterial competitive exclusion via the use of selected probiotic bacteria.

SET-UP

- The trials were realized in 500m2 fully lined ponds, 1.2m deep.
- Prior to stocking, all material and pond surfaces were disinfected with Sanocare®PUR, to ensure the complete removal of possible pathogens, including bacterial biofilms.
- After the first pond was filled, no water was added or exchanged for the entire production cycle.
- Shade cloth was installed over the ponds to minimize competition and deviation of the physico-chemical parameters due to the phytoplankton population.
- The aeration system was composed of 1" aero-tube diffusers, air supplied by root blowers. Two long-arm paddle wheels were installed as back-up.
- The water used was previously disinfected and treated to ensure the absence of pathogens.
- All ponds were stocked with selected genetic lines of post-larvae (PL10).
- High quality shrimp feed of 40% protein was distributed manually till 1g (crumble), then 24/24H pellet feeding was given via the use of automatic spinner feeders.

TRIAL PROTOCOL

During production, two INVE Aquaculture probiotic products were used to achieve bacterial competitive exclusion of Vibro sp.:
- Sanolife®PRO-W for water conditioning.
- Sanolife®PRO-2 as feed coating to improve the shrimp's gut bacterial ecology.

During the first month of farming, INVE Aquaculture's nursery feed supplement Sano®S-PAK was used as immunostimulant to improve the shrimp's resistance against environmental stress (density).

TRIAL RESULTS

Thanks to the complete absence of water renewal and the indoor production, the impact of environmental and meteorogical variables was minimal, resulting in very consistent results.

GROWTH, STOCKING DENSITY AND YIELD

The best economic output of the protocols resulted from a stocking density of 250 PL/m2. Growth, survival and FCR differences at higher densities were minimal (<5%), but the productivity increase was not high enough to compensate for the increase in PL and feed cost and production time.

NITROGEN CONTROL

We observed a complete control of nitrogen concentrations throughout the farming process: NH_3-N was maintained below a concentration of 0,5 ppm, NO_2-N below 2 ppm. With the optimization of multitrophic nitrification processes, the trial managed to address one of the major challenges in developing effective zero water exchange protocols: avoiding the ammonia and nitrite spikes that often impact overall productivity.

BENEFITS AND COST SAVINGS

Water quality control and the use of high quality probiotics and immunostimulants reduced the environmental stress on the animals, resulting in less size variation at harvest.

The optimal nitrogen control took away the need for water exchange, which considerably increased the biosecurity of the production system. At the same time, the trial managed to lower production costs due to lower power consumption (no pumping for water exchange) and less need for manpower (no bottom siphoning, pump operation and maintenance).

ABOUT INVE AQUACULTURE

For over 35 years INVE Aquaculture has been enabling growth in aquaculture. The healthy growth of fish and shrimp, the growth of our clients' local businesses and the growth of global aquaculture. INVE Aquaculture has become part of Benchmark, an aquaculture biotechnology business. Together the group offers a complete package of nutrition, health and genetic solution across all the major aquaculture markets.

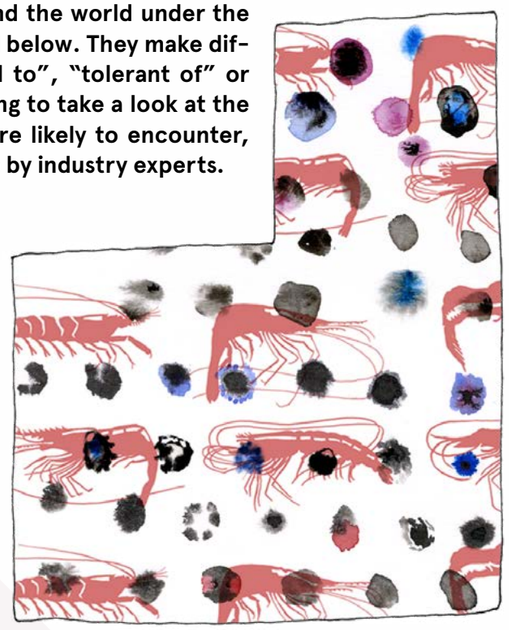
inveaquaculture.com
benchmarkplc.com

Names and Claims in Broodstock Trade

To better understand the dynamics of the SPF broodstock market, you first of all need to fully understand the terms used when talking about broodstock in general. Broodstock are sold around the world under the various terms that will be described in more detail below. They make different claims about being "free of" or "exposed to", "tolerant of" or "resistant to" certain pathogens. Here, we're going to take a look at the definitions of the main types of broodstock you're likely to encounter, and examine some of the claims about them made by industry experts.

SPF BROODSTOCK

Specific pathogen free (SPF) shrimp broodstock, mainly produced in Hawaii, mainland US and Thailand, can only be defined as such if they come from a population that has tested negative for all of the specific pathogens listed by the OIE for at least 24 months. They must be grown in biosecure facilities and must be fed with biosecure feeds. To maintain SPF status, a surveillance program for the specific pathogens must be in place. A list of the pathogens it is claimed the animals are free from should always accompany the broodstock when sold. SPF shrimp are not necessarily more resistant to or more tolerant of pathogens compared with non-SPF shrimp: "SPF" refers exclusively to the health status of a shrimp stock.[1]

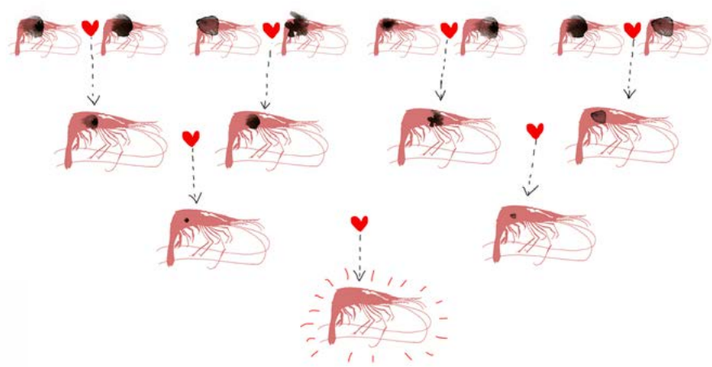


APE BROODSTOCK

All pathogens exposed (APE) broodstock, mainly produced in South and Central America, are broodstock produced by selecting strong performers from several successive generations under non–biosecure farming conditions in a region where several known and unknown pathogens are present. The term "all pathogens exposed" is somewhat misleading because not all pathogens occur in every geographical region and, as such, APE broodstock are not exposed to "all" pathogens but only to some pathogens, in the same way that SPF broodstock are not free of all pathogens but are free of those pathogens tested for. As opposed to SPF broodstock, APE broodstock may be infected with pathogens. Consequently, many countries do not allow their industry to import APE animals. Similarly to how the term "SPF" is used, "APE" refers exclusively to the health status of the shrimp broodstock.

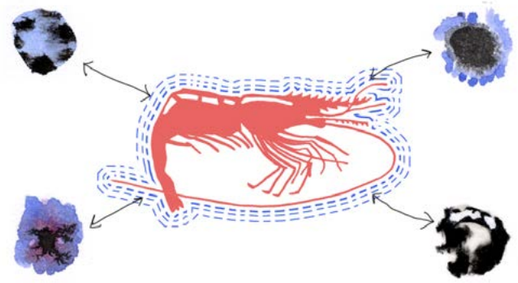
[1] V. Alday-Sanz et al., *Facts, Truths and Myths about SPF Shrimp in Aquaculture* (February 2020), Reviews in Aquaculture Vol. 12, Issue 1. See https://onlinelibrary.wiley.com/doi/10.1111/raq.12305.

[2] M. Salazar, *Pioneering Genetics* (2019), Benchmark Insights: Shrimp 2019, Issue 1, pp. 36-39. See https://www.benchmarkplc.com/wp-content/uploads/2019/11/Thought-Leadership-Magazine_Shrimp-Edition_Web.pdf.



CLEANSED/REVERSED SPF

Recently, some genetics companies have managed to develop an SPF broodstock from APE animals by using a process of continuous screening to select individuals that are shown to be free from the pathogens present on the OIE's specific list of pathogens for a period of at least 24 months. A broodstock generated in this fashion could be referred to as "cleansed" or "reversed" SPF. However, there is no agreement among experts as to whether these terms are scientifically justified. One supplier that sells SPF shrimp originating in Ecuadorian breeding lines promotes such shrimp under the term "High Vigor shrimp", emphasizing the superior survival rates of these animals in challenging environments.



SPR AND SPT BROODSTOCK

Contrary to SPF and APE, the terms "specific pathogen resistant" (SPR) and "specific pathogen tolerant" (SPT) do not refer to the health status of shrimp broodstock but to the way the shrimp deal with the pathogens: SPR and SPT say something about the actual genetics. According to Benchmark's Salazar,[2] resistance is defined as "the ability to limit pathogen burden". In other words, the ability to prevent an unwanted entity from entering the body. Tolerance, on the other hand, is "the ability to limit the damage caused by a given pathogen burden". In other words, the ability to live with the unwanted entity. In reality, these terms are used interchangeably and the only thing it is important to know for the buyer of such shrimp is which pathogens the animal is resistant or tolerant of. Therefore, as for SPF broodstock, if a line is marketed as SPR or SPT, the pathogen(s) the animals are resistant to or tolerant of should be listed when sold.

A Short History

In writing about the history of shrimp broodstock, *Shrimp Insights* aims to provide you with a summary of how the global market for specific pathogen free (SPF) *L. vannamei* shrimp broodstock has developed from its beginnings in the 1970s until the present day. Our hope is that understanding the "story" of this broodstock will allow you to better understand which products currently dominate the SPF *L. vannamei* shrimp broodstock marketplace, and, crucially, what to expect in the future.

MAKING WILD SHRIMP BROODSTOCK SPAWN IN CAPTIVITY

It was only in the mid-1970s that the first hatcheries in the US and Central and South America started to experiment with rearing *L. vannamei* and *P. stylirostris* PL in captivity. Both species are native to the Americas' Eastern Pacific coast from Sonora in Mexico through Central and South America as far south as Tumbes in Peru. It was, however, only once hatchery operators discovered that adult females spawn about two weeks after eyestalk ablation – the removal of one eyestalk of a female shrimp – that hatcheries finally managed to increase the consistency of post-larvae (PL) supply. As a result, commercial shrimp farming expanded across the Americas.

One of the major problems that soon arose when farmers started to use hatchery-reared PL was the occurrence of disease. This occurred due to the transmission of diseases from wild spawners to hatchery-reared PL, which would then contaminate the farming ecosystems. In the late 1970s, the infectious IHHNV hit shrimp farming areas across the Americas. IHHNV caused mortality rates of up to 100% among *P. stylirostris* farms. Although the disease also impacted *L. vannamei* – resulting in slow growth and deformity – the consequences were less severe than for *P. stylirostris*. As a result, *L. vannamei* soon became the preferred species across the Americas.

THE US: SPF SHRIMP AS A RESPONSE TO IHHNV OUTBREAKS

In response to the continuing impact of IHHNV on North American shrimp farms, in 1984 the United States Department of Agriculture (USDA) decided to finance the establishment of the US Marine Shrimp Farming Consortium (USMSFC), a consortium that would play a major role in the future development of SPF broodstock. In 1988, the USMSFC began to develop SPF shrimp: SPF shrimp would be free of all pathogens listed by the World Organisation for Animal Health (OIE) in its Aquatic Animal Health Code. The Oceanic Institute (OI) in Hawaii, the principal organization of the USMSFC, started to isolate wild-caught and hatchery-reared shrimp that were tested and found to be free of these OIE-listed pathogens. Animals from these populations were reproduced for several cycles and if the populations were still free of viruses after two years, the breeding program was certified by the USDA in Hawaii as being "SPF".

By 1991 the offspring of these populations were being used in commercial trials and the farms in the US using such offspring clearly outperformed farms that used non-SPF PL. Based on this success, in 1992 OI supplied all farms in the US and Hawaii with SPF PL. This resulted in the most successful crop shrimp farmers had ever seen. Supported by Akvaforsk, one of the world's leading genetics companies and nowadays part of Benchmark Genetics USA (Benchmark), OI began using SPF *L. vannamei* broodstock that was resistant to IHHNV in its breeding program as the founder population of a family-based selective breeding program in which other traits – in addition to being SPF – were selected, such as disease resistance.

In 1992, Jim Wyban, SPF broodstock pioneer and, at that time, the manager of the breeding program at OI, realized that these new broodstock could be commercialized and support shrimp producers around the world to overcome disease problems. However, OI was not yet ready to go down that path. So Wyban decided to start his own company, High Health Aquaculture, where he started his own breeding program with OI's founder stocks. Later, other companies in Hawaii followed his lead and together they made Hawaii into the world's capital for SPF broodstock.

In 1993, Wyban supported El Rosario, at that time a leading shrimp farmer in Ecuador, to renovate his Granjas Marinas hatchery to meet SPF requirements. One of Wyban's first export shipments of SPF broodstock was to Ecuador, and 500 million PL were produced from this broodstock. This PL were stocked in typical 20-acre ponds across the five farms of El Rosario. The hope was that the successful results observed in using SPF PL in the closed-system farms of the US would be repeated in the farms of Ecuador. However, it turned out differently. After 30 days, the shrimp in the ponds started to die. The SPF PL were susceptible to a new virus that was present in El Rosario's ponds: the TSV[1] – "SPF" does not relate to the shrimp's tolerance or resistance to disease; it is purely a sanitary status.

As a consequence, farmers in Ecuador and other Latin American countries realized that their large ponds without optimum biosecurity were not well suited to SPF PL, and they lost interest in it. Still today there is little or no interest in using SPF broodstock and PL in Latin America. With this loss of interest in SPF broodstock, Hawaiian producers shifted their focus to Asia.

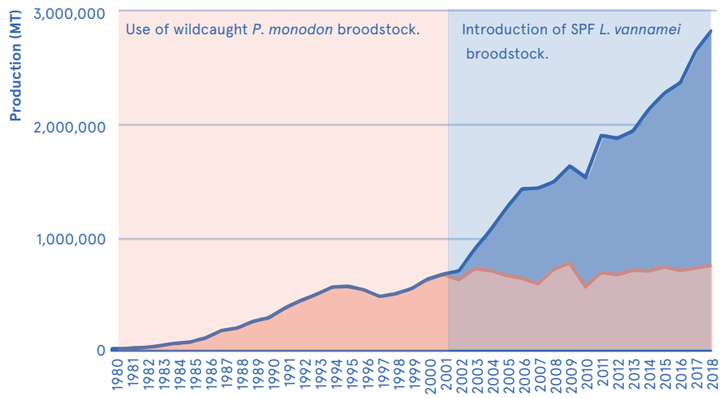
THE ASIAN CASE: SWITCHING SPECIES TO OVERCOME OUTBREAKS OF WSSV

Nowadays, *L. vannamei* dominates the Asian shrimp industry. However, it is not a native species to the region and was only introduced at scale in the early 2000s. Although some early introduction of *L. vannamei* PL happened in the 1980s in China and the Philippines, the preferred commercial species in Asia was, until then, *P. monodon*, a native species to most Asian geographies. This changed when WSSV – which first occurred in Taiwan in 1992 – spread throughout Asia and hampered the growth of the shrimp industry in many Asian countries.[2]

In 1996, when *P. monodon* farmers were suffering from the impacts of a WSSV outbreak, the first SPF *L. vannamei* broodstock were shipped from Hawaii to Taiwan. The first trials in Taiwan were highly successful and the use of *L. vannamei* broodstock and PL spread rapidly throughout the country's shrimp farms. In 1998, farmers in China also began importing SPF *L. vannamei* broodstock and replicated Taiwan's production results. However, the surging demand for SPF *L. vannamei* broodstock in Asia was too much for Hawaii's commercial producers to meet, and to bridge the supply gap, some producers in China began to select *L. vannamei* from their own ponds to use as broodstock in their hatcheries. At that time, operators in China did not differentiate health status from genetics and thought that they could reproduce an SPF animal from the pond. However, these animals were no longer SPF as they had been exposed to pathogens in the hatchery or farm, contrary to the conditions required to produce SPF broodstock as explained in the section on definitions on page 4.

Other producers in China took a different approach to sourcing enough *L. vannamei* broodstock: they started to import non-SPF broodstock from South America. As a result, TSV and IHHNV were introduced into China via these imported non-SPF broodstock and hampered the growth of production for a while due to outbreaks of these diseases amongst *L. vannamei* populations. Despite these setbacks, the industry in China recovered within a couple of years and the majority of farmers in China shifted from producing *P. monodon* and other local species to the culture of *L. vannamei*.

FIGURE 1: PRODUCTION GROWTH AFTER THE INTRODUCTION OF *L. VANNAMEI* INTO ASIA (EXCLUDING CHINA)[3]



[1] D. Garriquez & J. Wyban, *Recent Advances in Shrimp Hatchery Technology Including Use of High Health Shrimp Broodstock* (1993). J. Passoa, *Proceedings of the 3rd Brazilian Shrimp Farming Conference* (November 1993).

[2] See https://www.cabi.org/isc/datasheet/59574.

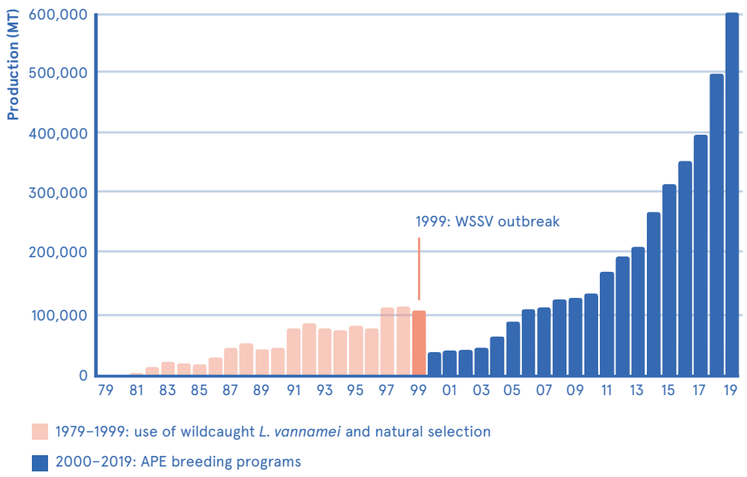
[3] Source: FAO FIGIS. China data has been excluded due to the assumed inaccuracy of production numbers for China in FAO FIGIS.

Other Asian countries soon followed Taiwan and China.[4] To combat the prevalence of WSSV, SPF *L. vannamei* broodstock were also introduced into Thailand and Vietnam in 2001, in Indonesia and Malaysia in 2002, and eventually also in India in 2009, first of all with commercial trials, and then fully in 2011. Other Asian shrimp farming countries that were slow to allow the production of *L. vannamei*, those being Sri Lanka (2019) and Bangladesh (pilots approved in 2019), are now starting to introduce *L. vannamei* to support their shrimp industries.

LATIN AMERICAN PRODUCERS DEVELOP APE BREEDING PROGRAMS

It was only after 1999 when Ecuador was confronted with a WSSV outbreak, halving the country's shrimp production, that Ecuadorian producers started to look for a better way to produce their broodstock. Based on natural selection, producers would select the largest and fittest animals from their ponds and use those as parents for successive generations. The shrimp that survived the larval stages in the hatchery performed well in ponds and successfully spawned in captivity. These genes were then passed on to the next generation. In this way, performance improved steadily generation after generation, and broodstock became increasingly tolerant to WSSV. As Figure 2 shows, Ecuador's new breeding strategy after the WSSV outbreak in 1999 has supported a surge in production over the past 15 years.

FIGURE 2: ECUADORIAN SHRIMP FARMING ANNUAL PRODUCTION[5]



Some of the breeding programs in Ecuador further developed into full-fledged family breeding programs. However, others, maybe the most successful ones, applied mass selection programs with aggressive and rigorous selection for growth while managing inbreeding. The use of improved broodstock from these breeding programs has played an important role in the recovery and rapid growth of Ecuador's shrimp production over the past decade. This is illustrated in Figure 2. The broodstock from these programs are mostly APE broodstock. As explained in the section on definitions on page 4, just like the term SPF, "APE" is merely a sanitary status; it says nothing about the broodstock's tolerance to disease.

A dichotomy in breeding strategies has now emerged: one strategy, that of North America, uses populations selected for their absence of pathogens and manages these populations in highly biosecure disease-free conditions. This results in SPF broodstock. The other strategy, that of Latin America, uses populations selected in the presence of multiple pathogens that are common in the local context. This results in APE broodstock.[6]

"CLEANSED" SPF LINES: COMBINING THE TOLERANCE OF APE SHRIMP WITH THE DISEASE-FREE STATUS OF SPF SHRIMP

Although APE broodstock have proven their success in the Ecuadorian context, these shrimp were not safe to trade internationally. The animals were robust and showed high survival rates and tolerance to WSSV, but they were not SPF: they could be carriers of pathogens and could introduce new diseases to other geographies. Pescanova, one of the world's largest vertically integrated shrimp companies and a major player in the shrimp industry with subsidiaries in Ecuador and Central America, started to develop SPF broodstock in early 2000 from the Ecuadorian APE broodstock with a high tolerance to WSSV. These animals would later be referred to by Alday-Sanz et al. as "cleansed" or "reversed" SPF broodstock. [7]

[4] J. Wyban, *Thailand's White Shrimp Revolution* (May/June 2007), Global Aquaculture Advocate, pp. 56-58.

[5] Modified from: J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.

[6] V. Alday-Sanz et al., *Facts, Truths and Myths about SPF Shrimp in Aquaculture* (February 2020), Reviews in Aquaculture Vol. 12, Issue 1. See https://onlinelibrary.wiley.com/doi/10.1111/raq.12305. See https://onlinelibrary.wiley.com/doi/10.1111/raq.12305.

[7] Idem.

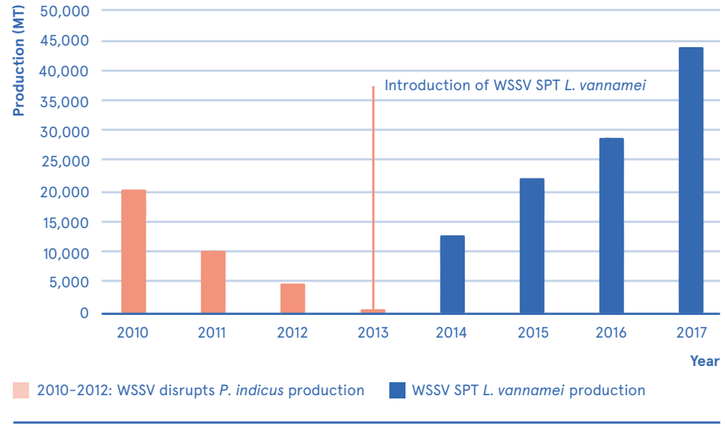
In 2010, Pescanova started the process of selecting shrimp that were free of all OIE-listed pathogens from the ponds that were stocked with APE WSSV-tolerant stocks in Ecuador and began to breed these for several generations. After three production cycles, two years later in 2012 the shrimp were tested to be free of the OIE-listed pathogens and the facility in Ecuador became the first SPF certified facility in the world that could offer cleansed or reversed SPF broodstock.

Saudi Arabia, at that time battling WSSV which had decimated the *P. indicus* shrimp production of the state-owned NAQUA, decided to import Pescanova's cleansed *L. vannamei* broodstock that were SPF and had a high degree of tolerance to WSSV. Within a couple of years of the company starting to use the cleansed SPF broodstock, production fully recovered.

Some companies in the US started to look at this technology as well. Primo Broodstock, a genetics SPF *L. vannamei* broodstock producer from the US and at that time based in Texas, was one of the first companies in the US to start breeding new genetic lines from animals that were imported from Ecuador. They set up a breeding program with these animals that would eventually be certified SPF for OIE-listed pathogens by the University of Arizona's pathology lab.

American Penaeid Inc., one of the biggest broodstock producers in the world, now sells a crossbreed of animals from the US and those that originate in Ecuador with cleansed SPF status, and has been doing so since 2017. The company refers to such broodstock as "High Vigor" shrimp, claiming overall robustness of the animals in challenging environments. Since the company started to offer High Vigor broodstock to the market, it has taken over a large share of the Chinese broodstock market.

FIGURE 3: RECOVERY OF SHRIMP PRODUCTION IN SAUDI ARABIA AFTER INTRODUCING CLEANSED SPF BROODSTOCK[8]



COMBINING TOLERANCE, GROWTH AND OTHER PERFORMANCE INDICATORS

While the most important thing for a shrimp farmer is that the shrimp in their ponds do not die, the second most important thing that makes or breaks the profitability of a shrimp farm is that the shrimp grow quickly: the faster the shrimp grow, the better the economics are in terms of feed costs, disease exposure, and the number of crops per year.

With diseases remaining the main risk for shrimp farming operations worldwide, breeding companies continue to primarily focus on producing SPF broodstock that is tolerant to specific pathogens. For a long time, the focus on disease tolerance was believed to have a negative impact on other traits, such as growth. However, new DNA technologies allow broodstock companies to better select animals according to specific traits. The result is that most companies have started to offer different breeding lines to the market that promote either disease tolerance or growth, or the right balance between both of these; broodstock buyers can select the animals that best fit their specific context. Overall, continuous innovations in breeding programs will result in more robust animals being bred that grow faster.

New technologies also allow broodstock companies to select other traits, such as performance in high and low-salinity environments, growth performance with lower levels of animal protein in shrimp feed, or fast growth rate. This development results in more environment-specific lines being offered to the market. Selecting traits specific to the shrimp is now a global trend, and is used by APE, cleansed SPF and natural SPF broodstock companies alike. With specialized companies such as Hendrix Genetics, Benchmark, and CP Foods becoming involved in shrimp genetics, it is likely that developments will go even faster than before, and that genetics will play a key role in how the industry grows in the future.

[8] Modified from: V. Alday-Sanz et al., *Facts, Truths and Myths about SPF Shrimp in Aquaculture* (February 2020), Reviews in Aquaculture Vol. 12, Issue 1. See https://onlinelibrary.wiley.com/doi/10.1111/raq.12305.

Photo: Jim Wyban

Some of the members of the USMSFC in the 1990's

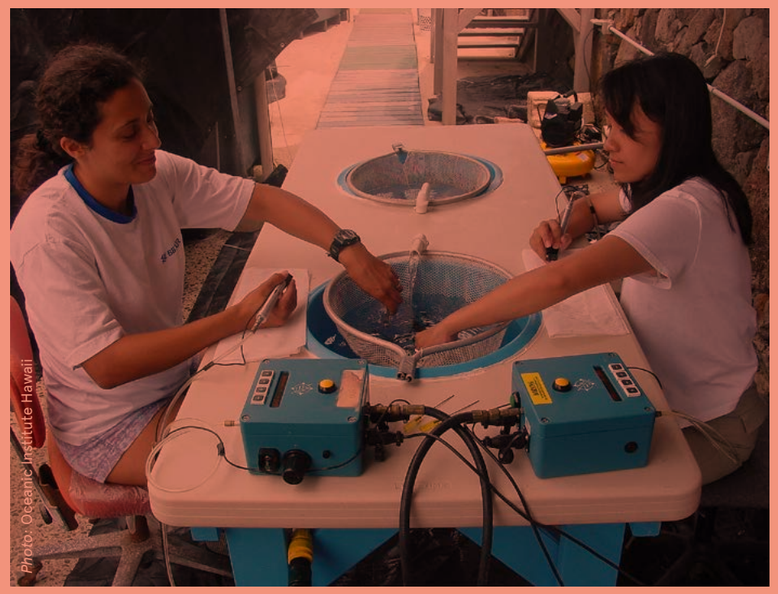


Photo: Oceanic Institute Hawaii

Broodstock tagging in the 1990's

Photo: American Penaeid, Inc.

API's high throughput DNA lab in Florida, USA

Artemia out of the Box

By: Luc van Nieuwenhove, I&V-BIO, www.iandv-bio.com

Since the beginning of shrimp aquaculture, artemia was recognized as a good nutritional feed for small shrimp and fish larvae. The fact that the artemia cysts could be dried and stored for a long time made it convenient for farmers. Ever since the early 1980s, shrimp hatcheries have been using artemia cysts in the same way. The suppliers offer dry cysts in a can or bucket. The hatchery is responsible for hatching the cysts into swimming Instar1 nauplii.

THE CHALLENGES AND CONCERNS OF PRODUCING ATEMIA NAUPLII FROM DRY EGGS

It seems easy to produce clean artemia nauplii from dry eggs but there are several challenges along the way:

1) Need for good-quality artemia eggs (hatching %)
2) Need for clean seawater at the right temperature
3) Need for sufficient light
4) Need for sufficient oxygen
5) Harvesting at the right time to collect the maximum of Instar1
6) Separating the live artemia nauplii from shell and impurities
7) Avoiding damaged nauplii as they will be a substrate for bacteria
8) Controlling the bacterial load throughout the whole process
9) Buying artemia cysts stocks is an important cash-drain for the hatchery
10) Hatching output can be very different from the claim on the packaging
11) Need for lab equipment to check for artemia stage, Vibrio and other viruses

The biggest concerns for shrimp hatchery managers are:

- Will I have enough artemia nauplii for today?
- Will these artemia nauplii be contaminated with Vibrio?
- Will I be able to separate the cyst shells without damaging the artemia nauplii?
- How do I know how much artemia nauplii I am feeding to each shrimp tank?
- Which brand do I buy?
  There are over 100 artemia cyst brands out there.

All these unknown factors result in frustration with shrimp hatchery owners and managers, who would much rather focus on shrimp cultivation rather than putting so much time and effort in hatching artemia cysts. For them, it is very disappointing to be confronted with hatching results not matching the promises of the cyst supplier and the unknown consequences of feeding artemia nauplii loaded with bacterial contamination.

To become less dependent on artemia, many R&D projects were set up with the goal of reaching that holy grail of artemia replacement. Many attempts were made, but the results never came close to feeding live artemia nauplii in the early larval stage of fish or shrimp. The higher the percentage of artemia replacement, the lower the growth and survival rate of the aquatic animal.

With a lack of alternative solutions, the demand for artemia cysts remains high but the focus is on high grade, easy-to-hatch artemia cysts. A considerable volume of cysts with lower hatching don't make it to the market because they are too difficult to hatch. With the aquaculture industry and demand for artemia growing, it is crucial to find ways to use all the artemia cysts available and not just the top hatchers.

As the shrimp industry rapidly evolves to a more professional and controlled production – from broodstock to market-size shrimp – the feed industry is tasked with keeping the same pace related to R&D. Although a lot has been achieved through improved feed formulation, development of probiotics and more ecological awareness of the impact of shrimp feeds, not much innovation has occurred on the artemia front.

The daily hatching of artemia hasn't improved much. Neither the packaging nor the instructions for use were ever changed. Some efforts were made to improve the separation technology, but this is just a small step in the overall artemia hatching process. So far, the best solution the artemia cyst industry could come up with was supplying dried artemia cysts in a can, but this was far from ideal for hatcheries. As I&V-BIO believes that hatching artemia should not be a headache for hatchery managers, we have come up with a solution.

"I&V-BIO'S KEY TO SUCCESS IS OUR GUARANTEE TO SUPPLY OUR CUSTOMERS WITH DAILY FRESH, CLEAN AND DISINFECTED VIBRIO-FREE PRODUCTS"

I&V-BIO SOLUTIONS

Eight years ago, I&V-BIO started working on a revolutionary solution which finally removes the artemia hatching burden from shrimp hatcheries by creating artemia hatching facilities with the know-how, experience and new technologies to produce artemia nauplii in a professional and industrial way. Currently, the I&V-BIO Group has established nauplii centers in Thailand, India (3), Indonesia, Vietnam and Ecuador. Bangladesh will be ready in early 2021.

All I&V-BIO artemia centers use a patented new technology with which they can offer pure undamaged artemia nauplii (Instar1) free of shell and other impurities, and free of Vibrio. The artemia nauplii are disinfected, brought into suspended animation and dewatered until a consistent live paste is achieved (72,000 Instar1 per gram). They are then packed into 800 g trays and delivered to shrimp farms daily. One tray of 800 g nauplii equals (in biomass) a cyst can with a 70% hatching rate. The artemia nauplii are ready for use and can be scooped directly from the tray into the shrimp tank. When the nauplii are introduced into the tank water, they wake up and start swimming.

Separation technology, disinfection and packaging are equally important in producing consistent quantity and quality. Customized computer programs combined with trained staff ensure on-time deliveries 365 days a year. I&V-BIO developed a unique separation technology with hatching and quality protocols which ensure industrial-scale artemia nauplii production. All our facilities are equipped with a water treatment (ozone) and ultra-filtration system (0.01 micron) as well as all necessary back-ups, such as two stand-by generators, water storage, spare parts and other stocks. We also invested in a "real-time PCR" which analyses all our produced batches daily for EHP, EMS and DIV1.

I&V BIO ... a better choice

INSTART ①

M-Bryo

INSTART Energy

OUR PRODUCTS

INSTART 1

is recognized for its pure Instar Artemia nauplii; no impurities, no damaged animals, no Vibrio and offered in a consistent live-paste (800 g per tray) setting a new standard in the shrimp industry. INSTART 1 enables the hatcheries to follow strict biosecurity protocols relieving them of the burden of hatching Artemia cysts in often suboptimal conditions.

INSTART ENERGY

To further strengthen the health of shrimp PL, I&V-BIO also offers INSTART Energy (Enriched Artemia nauplii) to hatcheries, nurseries and grow-out. INSTART Energy is enriched with a high quality DHA emulsion, algal extracts high in amino acids and carotenoids, herb extracts, proven for its powerful anti-Vibrio effect and its prebiotic properties and last but not least, extra Vitamin C and yeast-Selenium.

M-BRYO

We also offer decapsulated cysts (M-BRYO) in a paste form similar to our INSTART 1 in trays of 800 g. This is a fresh product produced without hypochlorite. The M-BRYO have intact membranes and are offered with the same QC standards such as clean and Vibrio-free. (Processed (dry) shell-free have always damaged membranes which burst as soon as they are hydrated.)

FEEDS

I&V-BIO also offers a range of high quality diets from zoeae until nursery. Starting from next year, a second feed-line will be launched produced with a new groundbreaking and patented technology. Most important advantages will be more uniform sizes, minimal leaching and no dust.

COPYCATS

While there are some companies trying to copy our concept, our INSTART 1 remains unique. Keeping the artemia nauplii undamaged, Vibrio-free and alive, requires more than just a few hatching tanks. Timing the harvest to ensure that 90% of all harvested nauplii are Instar1, requires skilled people and custom-made software. I&V-BIO uses its own patented separation and hatching technology developed by Luk Van Nieuwenhove.

GOAL

The goal of I&V-BIO is to be the preferred supplier of high-tech consistent products, being both easy to use and with daily delivery directly to the end user. We want to be present in all main shrimp and fish markets world-wide through the establishment of local facilities with local partners.

Broodstock Supplies During and After covid-19

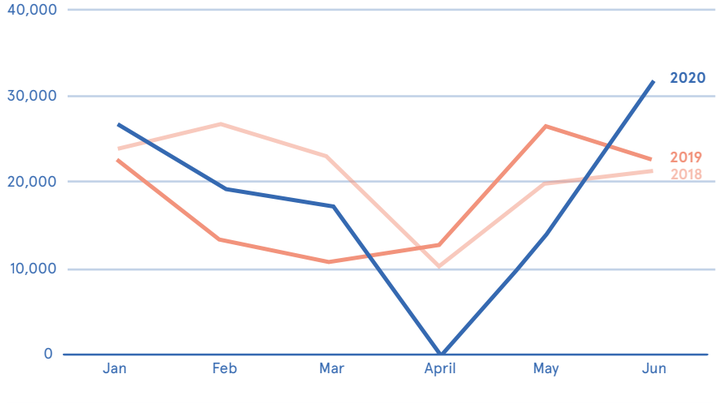
As most broodstock is transported internationally by air cargo, the outbreak of Covid-19 posed a serious problem for broodstock logistics during the first half of 2020. Normally, broodstock would be shipped via regular flights from Texas, Florida, Hawaii or Thailand to their final destinations in Asia or any other market. In the beginning of 2019, farming and market conditions were good in most Asian countries and hatcheries imported significant amounts of broodstock. However, when Covid-19 spread and airlines cancelled their flights, broodstock suppliers and hatcheries in Asia got into trouble and had to find other ways to provide their customers with broodstock. So, hatcheries and broodstock suppliers joined forces and chartered flights to keep their business going.

INDIAN BROODSTOCK IMPORTS CEASED ENTIRELY IN APRIL BUT RECOVERED IN MAY AND JUNE

India was well on track with its broodstock imports in the first three months of 2019. While it was 15% behind the import level of 2018, with 63,430 broodstock in the first quarter of 2020, imports were well ahead (+35%) of 2019's import levels in the same period. During the pandemic, hatcheries had closed down their operations for over a month, but once they were allowed to re-open, broodstock was still readily available and production could be restarted.

In May, the first imports arrived again. Six hatchery operators chartered a flight that would bring broodstock from Florida to India. This charter flight brought the first 3,600 broodstock into the country. In May, another 13,786 broodstock were shipped to India from Florida and Hawaii. Shrimp Improvement Systems (SIS) accounted for more than 70% of this number. Other suppliers included Kona Bay Shrimp (Kona Bay), Blue Genetics and American Penaeid Inc. SyAqua, for the first time since it obtained approval to export to India, shipped 1,200 broodstock to India in May.

FIGURE 1: INDIA'S BROODSTOCK IMPORTS FROM JANUARY–JUNE IN 2018, 2019 AND 2020[1]



More charter flights, but also regular cargo flights, followed. According to *Aquaculture Spectrum*, Kona Bay shipped almost 14,300 broodstock to India in June.[2] That same month, SIS exported 19,550 broodstock, and Sea Products Development supplied 1,200 broodstock. Together, June supplies of Kona Bay, SIS and SPD amounted to 35,550, well above India's import volumes in June 2018 and 2019.

Looking at India's year-to-date total in June, total broodstock imports were equal to the same period in 2019 and just 13% behind the same period in 2018.

[1] Source: *Aquaculture Spectrum*.

[2] Idem.

BROODSTOCK IMPORTS TO VIETNAM AND THE PHILIPPINES SHOW A SIMILAR TREND

According to quarantine data of Ninh Thuận Province[3] (responsible for around 35% of total broodstock imports) in Vietnam, the region imported 32,000 broodstock in the first half of 2020. Imports in 2020 started with 1,600 broodstock in February, increased to 8,000 broodstock in March, and then dropped again to 2,500 broodstock in April. In May and June, broodstock imports totalled 8,000 and 12,000 respectively.

Imports to the Philippines declined in the first six months of 2020. The country only imported 7,200 broodstock, compared to 10,200 broodstock in the first half of 2019. While imports were fairly high in January 2020 at around 2,900 broodstock, imports stopped entirely in February and remained stuck at around 1,200 broodstock in March, April and June. As with imports to India, some suppliers (e.g. Kona Bay) have been using charter flights to continue to supply their customers in the Philippines.

OTHER SUPPLIERS STRUGGLED WITH LOGISTICS FOR A MONTH BUT MANAGED TO KEEP THEIR OPERATIONS RUNNING

Robins McIntosch, who is in charge of CP Food's (CPF) breeding program in Thailand, explains that due to the nationwide Covid-19 lockdown, CPF's broodstock facilities went into lockdown as well. Staff were requested to stay at the facilities and no one was allowed to visit until the lockdown ended. This did not impact the staff much, as they were used to living at the facilities for extended periods of time and only take time off according to a rotating schedule.

Logistics were rather complicated during the lockdown. Road travel outside your own residential area, and of course air travel, were restricted. Luckily, CPF had already supplied its hatcheries in Vietnam and the US with sufficient broodstock for four or five months before the lockdown was enforced. Nevertheless, to complement supplies to Vietnam, the company chartered flights and, whenever space was available on cargo flights to China, it would take that opportunity to supply its hatcheries there.

SyAqua and Benchmark Genetics USA have also stated that logistics from their operations in Florida have been challenging during and after the lockdown. Although both are located close to three international airports, the frequency of flights to most Asian destinations was reduced drastically, and there was a lot of competition for the available cargo space. Moreover, once the broodstock had arrived at their destination, other challenges arose, such as transporting them to the hatcheries. The logistics departments of the companies needed to be very flexible and had to work closely with their customers, the airlines and the freight forwarders to keep their business going. All of this naturally resulted in higher costs. In most cases, these additional costs were shared between the broodstock suppliers and their customers.

THE SITUATION IN CHINA HAS BEEN AS WORSE AS IN INDIA

Robin Pearl, the owner of American Peneaid Inc. (API) and leading exporter to China, explains that the situation in China has also been challenging. While there was a planned shutdown of imports during Chinese New Year, shipments never resumed their full speed after that. API's shipments to China resumed in May and June, but volumes were far below those of 2019. In addition to Covid-19-related logistical issues, there was a change in import regulations and reportedly all permits of broodstock importers were cancelled and importers had to reapply for these permits. Many importers were not able to do so in time and thus could not import sufficient broodstock for the current season. So from February, API's exports to China have been very slow this year. However, there are positive signs as well. API has signed many new contracts for the upcoming season and many of its customers have increased their orders for this fall by an average of 20%. Considering all the challenges the industry is facing this year, the fact that hatcheries and farmers are confident to place such orders shows that they are confident that a new crop can be stocked during the fall season.

THE IMPACT OF COVID-19 ON LOGISTICS WAS MOSTLY FELT IN APRIL

Although imports slowed down or came to a standstill in most countries especially in April, it seems that they recovered quickly in May and June. This quick recovery was the result of the close cooperation between broodstock suppliers and their customers in finding solutions to keep business going. Broodstock suppliers and buyers initially decided to use charter flights or, when cargo space was available, used regular cargo flights to keep their supplies going. While Covid-19 has certainly had an impact on broodstock logistics, broodstock suppliers and their customers have shown flexibility and have been able to adapt to the situation rapidly. As a result, in most countries, hatcheries have been able to continue or restart production and to supply farmers with enough post-larvae so that they were able to start a new crop, or will do so soon.

[3] See http://chicuccntyninhthuan.gov.vn/tintuc/1018_Tin%20t%E1%BB%A9c%20li%C3%AAn%20quan.aspx.

Photo: Benchmark Shrimp Genetics

Market Size and Trade Flows

This section will introduce the sources and methodology we have used to make an estimation of the size of each specific pathogen free (SPF) *L. vannamei*[1] broodstock market and production cluster. Next, we will present our estimation of the market size of 2019 and an overview of trade flows, connecting the broodstock markets with the production clusters. This introduction will be followed by in-depth country profiles, in which you can read about the production clusters and markets in more detail.

SUMMARY

Broodstock supply: 1.4-1.7 million

Value $ million: 77-95

MARKET SIZE ESTIMATION – SOURCES AND METHODOLOGY

To make a good estimate of the global market for *L. vannamei* shrimp broodstock, one first needs to determine the number of broodstock imported and the number of F1 broodstock that is locally produced. Although there are various sources on which we can base estimations and determine the number of imported broodstock, there is hardly any reliable data on local broodstock production. Therefore, for the estimate of local production, this report depends on industry sources and the results of the *Shrimp Insights* broodstock market study.

The sources available for imported broodstock vary from one country to the next, and the data in this report are based on the most reliable sources. In general, the most reliable source of information are the broodstock import numbers from the government agencies responsible for monitoring the import of live animals for breeding in each respective country. Where this information was not available, the data in this report have been based on international trade data and on expert opinions. All sources and estimates have been verified with several industry experts prior to publication and are assumed to reflect the actual situation.

MARKETS	
China	China does not publish broodstock import numbers. International trade data on the value of broodstock are not accurate because significant numbers of broodstock are smuggled into the country. Therefore, the numbers in this report are based on industry sources.
India	India's broodstock import data for 2019 were published on a regular basis by the Coastal Aquaculture Authority and in the *Aquaculture Spectrum* magazine.[2]
Vietnam	Vietnam broodstock import data for 2017 and 2018 were published by the Vietnam Ministry of Agriculture and Rural Development (MARD).[3] As 2019 data have not yet been published, the report relies on industry sources for these numbers.
Indonesia	Indonesia does not publish broodstock import numbers. International trade data are generally accurate. The estimated number of imported broodstock is calculated by dividing the total value of imported broodstock by $55 per animal.[4]
Thailand	Thailand does not publish broodstock import numbers. International trade data are generally accurate. The estimated number of broodstock is calculated by dividing the total value of imported broodstock by $55 per animal.
Philippines	The Bureau of Fisheries and Aquatic Resources (BFAR) in the Philippines published broodstock import data for 2017-2019 on a continuous basis.[5]
Malaysia	Malaysia does not publish broodstock import numbers. International trade data are generally accurate. The estimated number of broodstock is calculated by dividing the total value of imported broodstock by $55 per animal.
Others	To get to a market size estimation of all other markets, the report relies on international trade data for Thailand and US broodstock exports. The value of exports is divided by $55 per animal to arrive at an estimate of total broodstock exports to other markets.

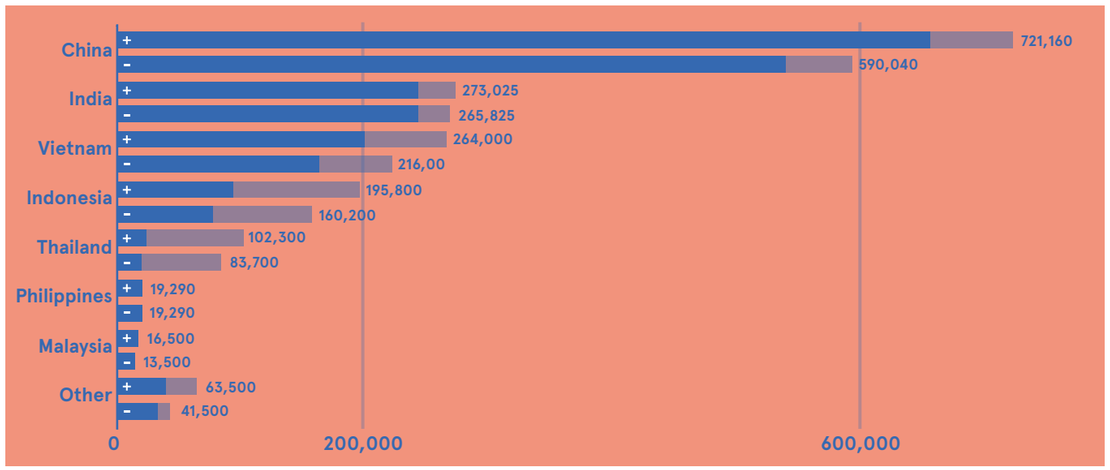
[1] All references are to SPF broodstock, unless specified otherwise.
[2] See https://www.aquaculturespectrum.com/.
[3] For the MARD official website, see https://www.mard.gov.vn/en/Pages/default.aspx.
[4] The average price per animal in 2019.
[5] For the BFAR official website, see https://www.bfar.da.gov.ph/.

MARKET SIZE

The biggest markets for F1 *L. vannamei* broodstock in 2019 were China, India, Vietnam and Indonesia (see Figure 1). The remainder of the market for F1 *L. vannamei* broodstock was comprised of smaller shrimp producers in Asia, such as Malaysia, the Philippines, South Korea, Sri Lanka and Taiwan, as well as several in the Middle East, Europe and the Americas.

PRODUCTION CLUSTERS	
Hawaii	Hawaii's export data from 2003-2019 have been published in several articles.[6]
Florida and Texas	Florida and Texas do not publish their broodstock export data separately. International trade data are incomplete, therefore the report relies on data reported by individual companies and industry experts.
Thailand	Thailand does not publish detailed broodstock export data. However, international trade data are comprehensive and considered to be reliable. These data, combined with data reported by individual companies and industry sources, are used for the current report.

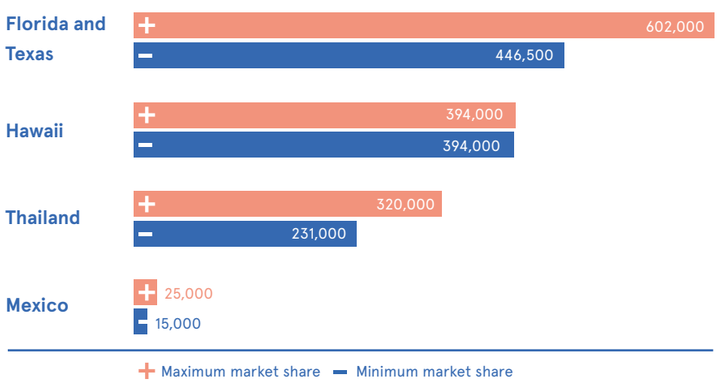
FIGURE 1: *SHRIMP INSIGHTS* ESTIMATE OF SIZE OF MAJOR F1 *L. VANNAMEI* MARKETS IN 2019



Although the number of NBCs and BMCs in shrimp-producing countries is increasing, currently only about 15% of the global broodstock market is supplied by domestic F1 *L. vannamei* broodstock producers. The largest part of the market (85%) is supplied by imported broodstock.

While *L. vannamei* broodstock production was initially concentrated in Hawaii, there are now four *L. vannamei* broodstock production clusters which not only supply domestically but also trade internationally: (1) Florida and Texas, (2) Hawaii, (3) Thailand and (4) Mexico (see Figure 2).

FIGURE 2: *SHRIMP INSIGHTS* ESTIMATE OF NUMBER OF BROODSTOCK EXPORTED IN 2019 FROM MAJOR *L. VANNAMEI* PRODUCTION CLUSTERS



[6] J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2019), Hatchery Feed & Management, Vol. 7, Issue 4, pp. 19-23. See https://issuu.com/aquafeed.com/docs/hatcheryfeed_vol_7_issue_4_2019/19. See also J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.

TRENDS

- The market size for F1 broodstock is expected to increase over the coming years alongside the growth of shrimp production. The F1 broodstock market may grow at a slower pace than farmed shrimp output when the efficiency of broodstock production and survival of broodstock and post-larvae improves.
- The market share of domestically produced F1 broodstock increases at the cost of imported F1 broodstock due to the establishment of nucleus breeding centers (NBCs) and breeding multiplication centers (BMCs) in Asia and the Middle East. These NBCs and BMCs can be locally owned, foreign-owned or can be a part of joint venture partnerships. More NBCs and BMCs are expected to be set up in the coming years.
- Market shares in China have changed drastically in favor of suppliers from Florida and Texas. While this trend is unlikely to change in the short term, depending on the development of disease tolerance in breeding programs of suppliers from other geographies, suppliers based in Florida and Texas may face increased competition in the future.
- In most South American markets, there is generally still no preference for SPF broodstock over all pathogens exposed (APE) broodstock. However, in those countries where farmers invest in more intensive production systems, such as Brazil and Peru, these farmers may prefer to use SPF broodstock, as it performs better in intensive production systems than APE broodstock.

COUNTRY PROFILES

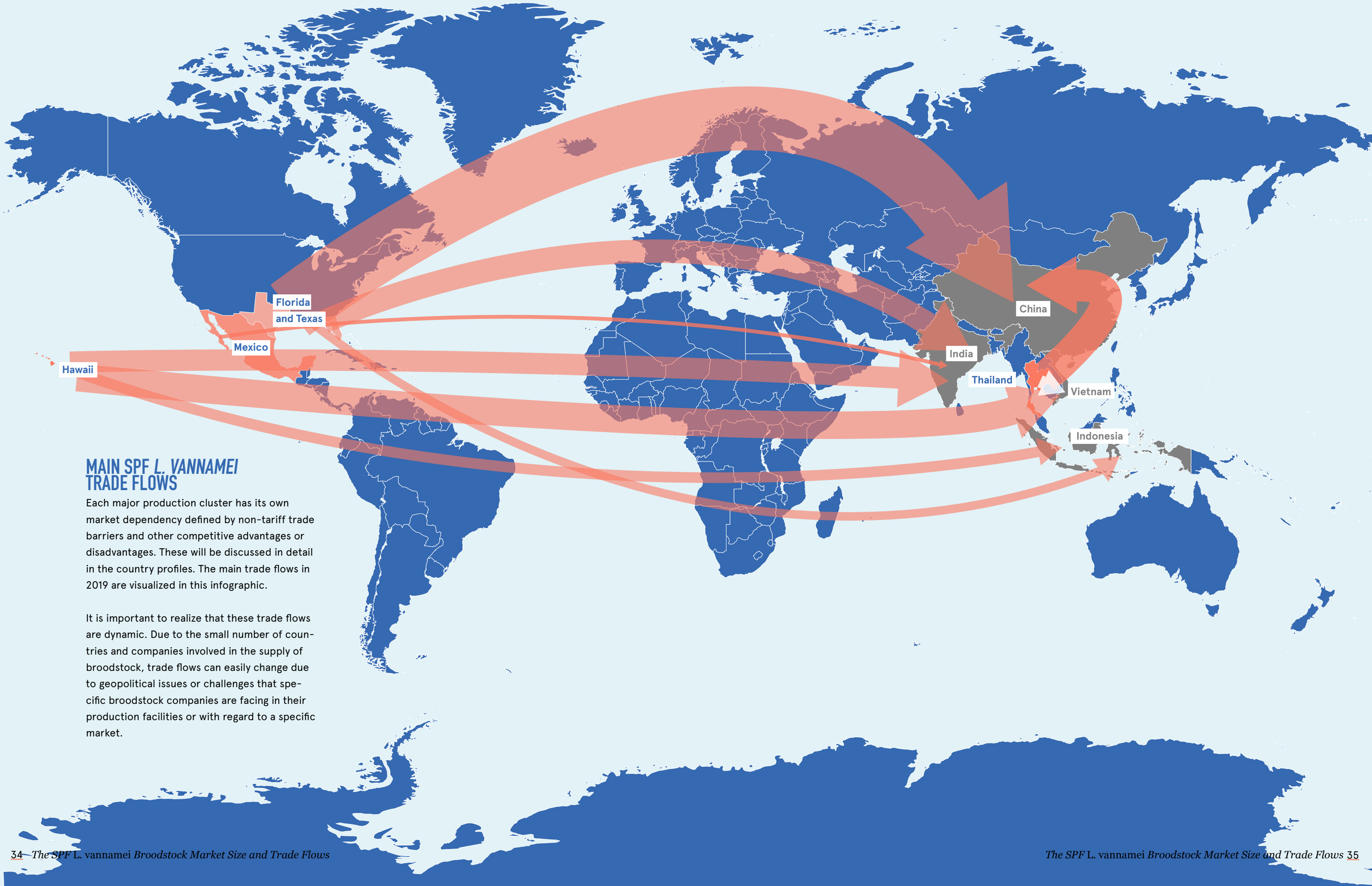
The country profiles that will follow from page 38 will give a detailed analysis of local broodstock production, imports and exports. They will provide insight into the key suppliers to a country, the major importers within that country and the most significant local producers. All profiles will include contextual information and detailed information on the market shares of the companies involved.

The exact calculation of the ranges of the number of broodstock provided in the country profiles that follow can be viewed in Annex 3. The value is calculated by multiplying the number of broodstock by the average price of $55 per broodstock. Numbers are rounded.

MAIN SPF *L. VANNAMEI* TRADE FLOWS

Each major production cluster has its own market dependency defined by non-tariff trade barriers and other competitive advantages or disadvantages. These will be discussed in detail in the country profiles. The main trade flows in 2019 are visualized in this infographic.

It is important to realize that these trade flows are dynamic. Due to the small number of countries and companies involved in the supply of broodstock, trade flows can easily change due to geopolitical issues or challenges that specific broodstock companies are facing in their production facilities or with regard to a specific market.



Broodstock Companies and their 2019 Market Shares

This section tells you all about the sources and methodology used to gather the information on the companies presented in this report. You will find a short, overarching analysis of the companies involved and their respective market sizes.

SOURCES AND METHODOLOGY

The company profiles in this report consist of information gathered from a variety of sources, including company websites, company reports from secondary online sources, articles from news sites, and the results of the *Shrimp Insights* 2019 survey.

After gathering the information, the next step was compiling draft company profiles based on company websites and secondary sources. These profiles were then sent to all broodstock companies involved, allowing them to edit and complement the information presented. Besides qualitative information, such as the different broodstock genetics lines they sell to the market, they were also requested to share quantitative information, such as the number of broodstock supplied to the market from 2017 to 2019 and which markets they supplied to. Thirteen out of fifteen companies responded to the *Shrimp Insights* 2019 survey. Several companies did reply but did not provide the requested quantitative information because they regarded it as confidential. In those cases the data will be marked "N/A".

In each profile, you will also find a *Shrimp Insights* rough calculation of the number of broodstock supplied to the market by each company in 2019 as well as an estimate of which markets each company supplied to. The approximate number of broodstock supplied by each company were calculated by adding up the volumes of every company in each market. The sum total per company was then multiplied by a factor of 0.9 for a minimum estimate and by a factor of 1.1 for a maximum estimate, allowing potential errors to be taken into account.

Data on broodstock imports into India and the Philippines leave little space for error, as they are official data provided by national authorities. In the case of Vietnam, 2018 official data were used as a proxy for 2019 as 2019 data have not yet been published. For the other markets, we relied on data reported by individual companies and estimates from secondary industry sources. The exact sources per country are disclosed in Annex 3. Where official data were unavailable, the risk of errors was more significant.

[1] All references are to SPF broodstock, unless specified otherwise.

COMPANIES WITHIN SCOPE

This report covers 15 companies that were active in the production and trade of SPF *L. vannamei*[1] broodstock in 2019 and that are responsible for at least 95% of F1 *L. vannamei* broodstock produced globally in 2019. Table 1 provides an overview of the companies within the scope of this report, when they started their breeding activities and where they are located.

TABLE 1: BREEDING COMPANIES WITHIN SCOPE

BREEDING COMPANY	SINCE	LOCATIONS
Molokai Broodstock Company (MBC)	1984	Hawaii
Oceanic Institute (OI)	1989	Hawaii
Kona Bay Shrimp	1996	Hawaii and Ecuador
Shrimp Improvement Systems (SIS)	1998	Hawaii and Florida and India
SyAqua	2002	Florida, Thailand and Indonesia
Charoen Pokphand Foods (CPF)	2003	Thailand, China, Vietnam, India, Malaysia, Philippines, the US, and others
Top Aquaculture Technology	2003	Thailand
Global Gen Indonesia (PT Bibit Unggul)	2006	Indonesia
Viet-Uc	2011	Vietnam
Primo Broodstock	2011	Texas and Florida
Sea Products Development (SPD)	2011	Texas
Blue Genetics	2013	Mexico and India
American Penaeid Inc. (API)	2014	Florida
North America Broodstock (NAB)	2016	California
Benchmark Genetics USA (Benchmark)	2016	Florida, Colombia and Thailand

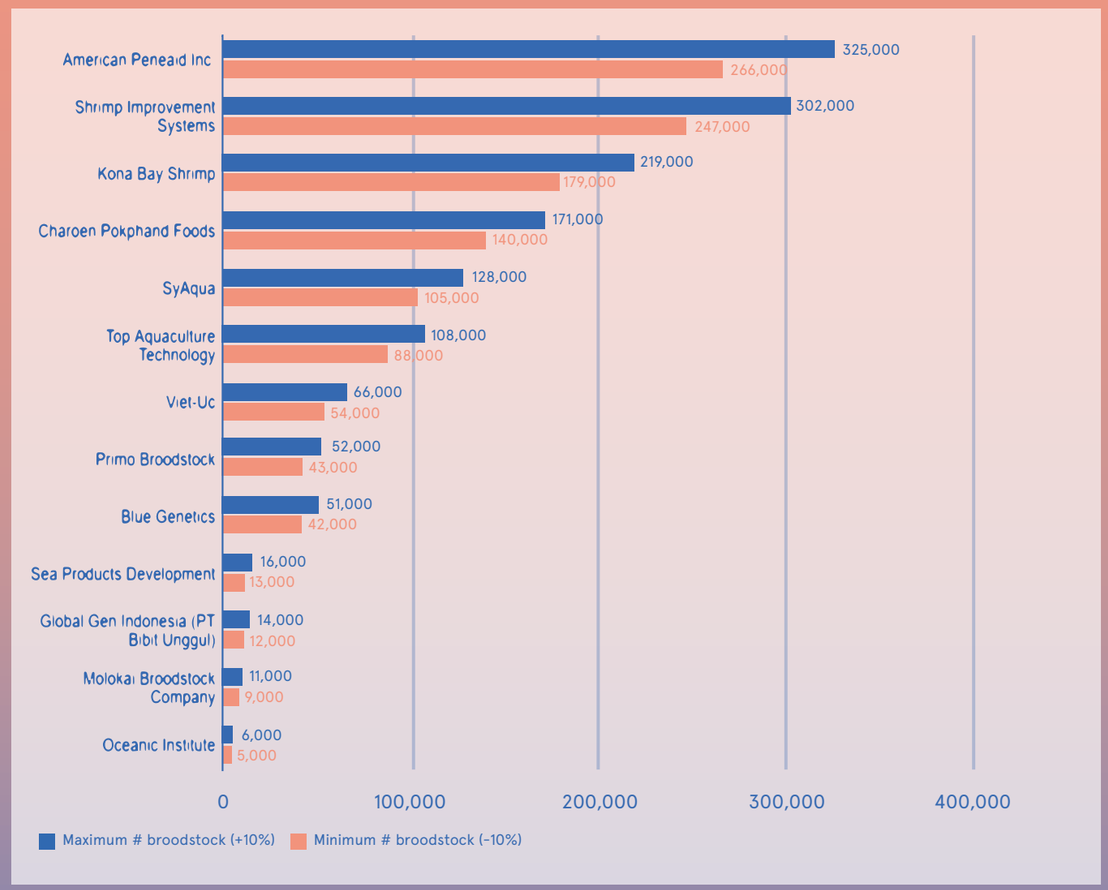
SHRIMP INSIGHTS ESTIMATE OF MARKET SHARES IN 2019

The top five *L. vannamei* broodstock suppliers in 2019, according to the *Shrimp Insights* estimate, were American Penaeid Inc. (API), Shrimp Improvement Systems (SIS), Kona Bay Shrimp, Charoen Pokphand Foods (CPF), and SyAqua. Jointly, these top five suppliers had a market share of 75-80% of the total F1 *L. vannamei* broodstock market. While SIS, Kona Bay Shrimp, CPF and SyAqua have been around for quite some time, API, potentially 2019's biggest supplier, only emerged as a major broodstock supplier in the past couple of years.

TRENDS

- Looking at other animal breeding sectors, the breeding segment within the shrimp industry is also likely to consolidate further in the long term. Breeding companies with reasonable market shares currently operating independently could especially be targets for acquisition.
- In the short term, increased competition from newcomers such as API, Benchmark and Viet-Uc may increase the pressure on market shares of other players previously dominating the market.
- With newcomers such as Hendrix Genetics and Benchmark, breeding programs will likely develop rapidly. These two companies bring experience from other animal breeding programs to the shrimp industry, resulting in innovations that will improve the future performance of *L. vannamei* broodstock.

FIGURE 1: *SHRIMP INSIGHTS* ESTIMATE OF MARKET SHARES IN 2019[2, 3]



[2] Benchmark Shrimp Genetics and North America Broodstock (NBA) are not included in Figure 1 because in 2019 they did not yet ship significant quantities of broodstock.

[3] Figure 1 includes a minimum and maximum estimate of the number of animals supplied to the market in order to compensate for errors in the exact estimate. The exact calculations are provided in Annex 3.

AMERICAN PENAEID INC.

American Penaeid Inc. (API) only started its breeding program in 2016. It used offspring of the OI program and Primo Broodstock animals – which it was outgrowing in its facilities in Florida in agreement with Primo Broodstock – and cross-bred those with some of its own animals to create a new hybrid. Primo Broodstock's animals originated from Ecuador and were APE. Through its own breeding program, API now produces API High Vigor, cleansed SPF *L. vannamei* broodstock. API has rapidly gained market share in China and is currently the country's largest supplier of SPF broodstock. API is currently attempting to expand to other markets such as Vietnam and India. In the last five years, API has grown into (one of) the world's largest *L. vannamei* broodstock supplier(s).

WWW.PENAEID.COM

owned by

AMERICAN MARICULTURE INC.

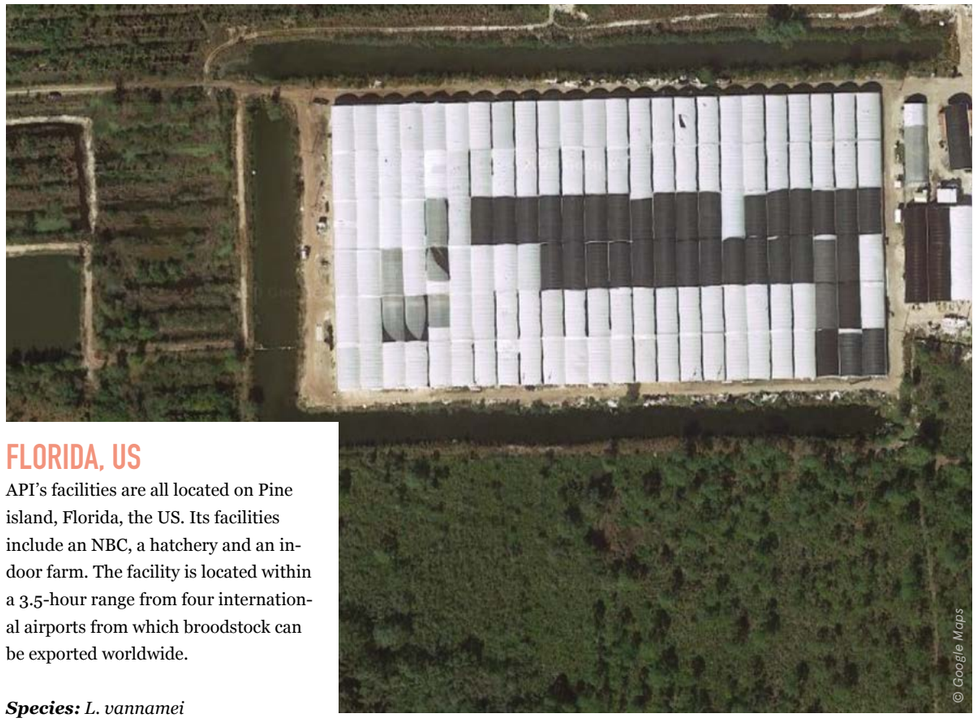
American Mariculture Inc. is the full owner of API. The company consists of a highly intensive shrimp farm located on Pine island in Florida founded in 2013. The company focuses on the production of shrimp for the US domestic market and produces all year round. The shrimp is sold under its Sun Shrimp brand and is supplied to retailers and wholesalers across the country. API's facilities include an on-site NBC, a hatchery, grow-out greenhouses, a packing plant, a lab and support facilities. The NBC, hatchery and farm use completely untouched water from a saltwater well that draws from the surrounding mangroves.

WWW.SUNSHRIMP.COM

Breeding lines

API High Vigor®

The API High Vigor® line is a cross-breed of stock originating from Ecuador (APE) and stock originating from Hawaii (SPF). API managed to breed the cross-breed to SPF status. The API High Vigor® line is not resistant or tolerant to specific pathogens but has a general high level of resilience.



FLORIDA, US

API's facilities are all located on Pine island, Florida, the US. Its facilities include an NBC, a hatchery and an indoor farm. The facility is located within a 3.5-hour range from four international airports from which broodstock can be exported worldwide.

Species: *L. vannamei*
Capacity in 2019: 1,000,000
Possible export markets: All

***Shrimp Insights* estimates in 2019**[1]	
Export market	**China (95%), India (3%), Vietnam (2%)**
Number of broodstock supplied to the market	**266,000–325,000**

	2017	**2018**	**2019**
Number of broodstock supplied to the market[2]	61,000	152,000	330,000

Export trends explained

API's rapid growth is connected to its expansion in the Chinese market, where farmers struggle with disease and where there is therefore much demand for broodstock and PL with a high level of disease tolerance and overall resilience.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[2] As reported to *Shrimp Insights* by the company.

SHRIMP IMPROVEMENT SYSTEMS

Founded in 1998, Shrimp Improvement Systems (SIS) is one of the largest shrimp broodstock producers in the world. The company was set up in Florida, the US, with an NBC and a BMC. In 2005, SIS established a BMC in Singapore which brought it closer to the Asian buyers of its broodstock. In 2012, SIS purchased High Health Aquaculture in Hawaii, which at the time was owned by Jim Wyban, one of the *L. vannamei* broodstock pioneers in Hawaii. In 2014, SIS invested another $10m in the infrastructure of its Hawaii facilities, which currently include a *P. monodon* and *P. stylirostris* NBC and BMC, and a separate *L. vannamei* NBC and BMC. In 2019, SIS had to close down its operations in Singapore due to its land lease contract expiring, making Hawaii the current headquarters of the company's breeding activities. Through an exclusive supplier relationship with CP Prima, SIS's share of Indonesia's broodstock imports was believed to account for 25-40%.

WWW.SHRIMPIMPROVEMENT.COM

SIS Florida is the facility in the Florida Keys where the company began its operations in 1998. It contains an NBC for *L. vannamei* and a BMC with the capacity to produce and ship 200,000 animals per year. Since opening its new facilities in Hawaii, most of the company's selective breeding programs are consolidated in Hawaii. However, the US facilities are still operational. In 2019, most of SIS's exports to India originated from Florida.

Type of facility: NBC and BMC
Species: *L. vannamei*
Capacity in 2019: 200,000
Possible export markets: All

INDIA

SIS operates two hatcheries in India. They are located in Kakinada and Bhogapuram and together can produce 100 million PL and 600 million nauplii per month.

Type of facility: BMC
Species: *L. vannamei*
Capacity in 2019: 200,000
Possible export markets: Only India

Breeding lines

SIS has no information about its breeding lines on its website. However, industry sources report that SIS promotes two genetic lines: one focused on growth and one on disease tolerance. On LinkedIn, in August 2020, the company announced the launch of a new breeding line especially developed for intensive shrimp farmers in Vietnam.

In 2012, SIS purchased Jim Wyban's High Health Aquaculture, then a leading broodstock producer in Hawaii. In 2014, SIS dedicated a $10m investment to a new *L. vannamei* NBC at the Natural Energy Lab of Hawaii (NELHA), located in Kailua-Kona, Hawaii. Besides their new *L. vannamei* breeding center, SIS's facilities in Hawaii house NBCs for *P. monodon* and *P. stylirostris* and a separate BMC for *L. vannamei* with the capacity to produce and ship about 300,000 commercial broodstock per year.

Type of facility: NBC and BMC
Species: *L. vannamei*
Capacity in 2019: 200,000
Possible export markets: All

SIS Singapore is a BMC that began operations in 2005 and has the capacity to produce and ship about 150,000 commercial broodstock per year. In 2019, SIS had to close its Singapore facility due to its land lease contract expiring. SIS was prepared for this development and had its facilities in Hawaii and Florida replace the products that were previously supplied from its Singapore facility.

Type of facility: BMC
Species: *L. vannamei*
Capacity in 2019: Ceased to exist in 2019
Possible export markets: All

***Shrimp Insights* estimates**[1]	
Export markets in 2019	**Vietnam (45%), India (35%), Indonesia (10%), and others (10%)**
Number of broodstock supplied to the market in 2019	**247,000-302,000**

	2017	**2018**	**2019**
Number of broodstock supplied to the market[2]	N/A	N/A	N/A

Export trends explained

The company has not provided any comments on its export trend. However, its export numbers are likely to show a slightly negative trend between 2017 and 2019.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[2] As reported to *Shrimp Insights* by the company.

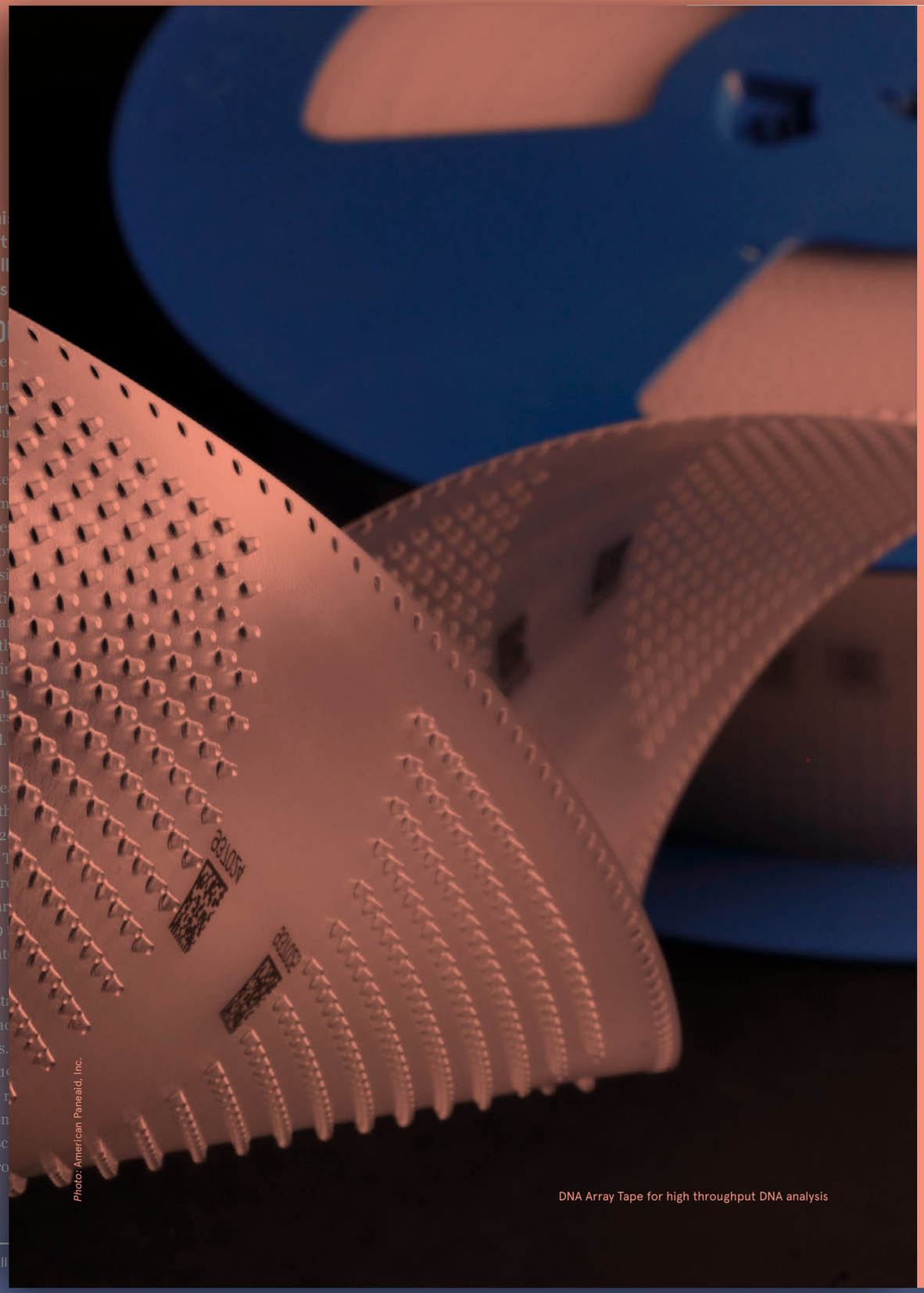


Photo: American Panelaid, Inc.

DNA Array Tape for high throughput DNA analysis

Photo: INVE

KONA BAY SHRIMP

Kona Bay Marine Resources was founded in 1996 and started its operations at the Natural Energy Laboratory of Hawaii Authority. In 2006, the company's operations were relocated to the island of Kauai, where it acquired the hatchery, farm and processing plant of Ceatech USA Inc, the largest integrated shrimp producer in Hawaii. In 2009, industry icons George Chamberlain and Kenneth Morrison, having sold their company Black Tiger Aquaculture (BTA) in Malaysia, purchased a majority share in Kona Bay Marine Resources. Together with Donald Lightner and Chris Howell, who worked with BTA as disease and hatchery specialists, they managed to develop Kona Bay into a world leader in L. vannamei broodstock. In 2017, Netherlands-based animal breeding company Hendrix Genetics acquired a majority stake in Kona Bay.[1] Since July 2020, Hendrix Genetics owns 100% of the company.

WWW.KONABAYSHRIMP.COM

owned by

HENDRIX GENETICS

Since 2017, Kona Bay has been part of Hendrix Genetics, a world-leading multi-species animal breeding company. This partnership aims to boost Kona Bay's shrimp breeding program by introducing advanced genetics and genomics technologies developed by Hendrix Genetics. The collaboration also provides the capital necessary for the development of state-of-the-art breeding facilities for both shrimp species in Kauai, as well as the development of model hatcheries for the production of quality PL in key market regions around the world. In addition, a comprehensive program for specific disease resistance has been implemented to further enhance the quality of Kona Bay broodstock. Hendrix Genetics is a privately owned company. Dutch investment fund SHV, which owns animal feed producer Nutreco and its fish and shrimp feed producer Skretting, owns a minority share of Hendrix Genetics.

WWW.HENDRIX-GENETICS.COM

Breeding lines

Speed

After years of careful selection for growth, and the acceleration through genomic selection, Kona Bay has developed the Speed line focused on optimal growth rates in a variety of production systems.

Balance

The selling points of the Balance line are simultaneously growth and disease resistance. With the Balance line, Kona Bay aims to provide farmers in more challenging environments with strong but fast-growing shrimp.

Strength

The Strength line is selected for its high disease resilience and aims to provide farmers in particularly challenging conditions with a strong animal with high survival rates.

[1] See https://www.hendrix-genetics.com/en/animalbreeding/shrimp-breeding/.

Kona Bay
Kona Bay Shrimp's NBC and BMC are located on the island of Kauai. Its facilities comprise the largest shrimp farm in Hawaii.

Type of facility: NBC and BMC
Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
All Markets

Macrobio SA
Hendrix Genetics, in partnership with Skretting and Ecuacultivos, has invested in Ecuador to establish a state-of-the-art shrimp hatchery. The hatchery will deliver high-quality, high-health PL to Ecuadorian farmers. The new joint venture has taken over the existing Macrobio hatchery[2] tand is upgrading its facilities and investing in a new breeding program.

Type of facility: BMC
Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
Only Ecuador

MALAYSIA

Kona Bay Malaysia
The company also operates a subsidiary in Malaysia. Previously known as iAqua Malaysia, Kona Bay Malaysia is a 100% owned subsidiary with its own BMC and NBC. The company sells nauplii and SPF SPT broodstock. Although Kona Bay Malaysia currently only sells to the Malaysian market, from the last quarter of 2020, the company plans to start selling to the Chinese market as well.

Type of facility: BMC
Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
Malaysia, China

***Shrimp Insights* estimates in 2019**[3]	
Export markets	**India (55%), Indonesia (15%), Vietnam (10%), Phillipines (5%) and others (10%)**[4]
Number of broodstock supplied to the market	**179,000–219,000**

	2017	2018	2019
Number of broodstock supplied to the market[5]	N/A	N/A	N/A

Export trends explained

Vietnam's provincial import data for 2020 reveal that Kona Bay not only exports broodstock to Vietnam, but also PL. If Kona Bay supplies PL to other markets in Asia as well, its actual market share in some of the markets might be larger than one would conclude based on broodstock import data. In general, with its breeding program under development, and potential investments in Asia underway, the company is expected to grow its numbers in the coming years.

[2] https://www.nutreco.com/en/News/Press-releases/nutreco-partners-with-hendrix-genetics-to-deliver-next-generation-of-premium/1595287.
[3] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[4] The export markets are an estimate of the company its facilities in Hawaii only.
[5] As reported to *Shrimp Insights* by the company.

CHAROEN POKPHAND FOODS

Charoen Pokphand Foods (CPF) is headquartered in Thailand and is one of Asia's largest conglomerates in the animal protein business. It was also one of the first companies to establish an NBC for SPF shrimp in Asia. Currently, CPF operates three separate NBCs and breeds different lines of *L. vannamei* and *P. monodon* broodstock. From its BMCs in Thailand, the company sells to its own subsidiaries worldwide. CPF has a network of subsidiaries in other Asian countries of which China, Vietnam, India, Malaysia and the Philippines are the most important. Although these subsidiaries often import CPF broodstock from Thailand, they are neither obliged to nor always able to do so. India, for example, has excluded Thailand as a broodstock supplier, hence CP Aquaculture India source broodstock from the US. Similarly, the Philippines has only recently allowed CPF to export broodstock to the country. CPF is now also active in the South American shrimp industry having invested in Brazilian shrimp producer Camanor in 2018.

WWW.CPFWORLDWIDE.COM

THAILAND

CP Foods

Thailand is CPF's global headquarters and its genetics and broodstock business is centered here. The company operates three isolated NBCs with three connected BMCs, two genetic backup centers and one disease challenge test center. The company also operates eight hatcheries throughout the country and is believed to own a market share of about 65% of Thailand's domestic market producing 35-40 billion PL per year.

Type of facility: NBC and BMC
Species: *L. vannamei* and *P. monodon*
Capacity in 2019:
Possible export markets:
All except India and Indonesia

CHINA

CP China

CPF's aquaculture-related businesses are owned by CP China, a fully owned subsidiary of CPF. CP China has three subsidiaries that focus on the production of PL: CP Dongfang, CP Zhanzhou and the recently established CP Zhanjiang. CP China also operates a number of aqua feed mills and farms in other provinces, such as in Hainan.

Type of facility: NBC and BMC
Species: *L. vannamei*
Possible export markets:
Only China

Breeding lines

CP TURBO

CPF's Turbo broodstock line focuses on fast growth but is also resistant to TSV, EMS and IHHNV. CP Turbo is the main product sold to the market.

CP KONG

CPF has recently announced the launch of CP Kong, which will combine growth (currently 80% of the growth rate offered by the CP Turbo line and improving every year) with tolerance to WSSV, and will continue the tolerance of CP Turbo to TSV, IHHNV and APHNS. This line is mainly aimed at less biosecure production systems.

OTHER BREEDING LINES

Besides these two lines, CPF is currently developing other lines. One of these is a fast-growth line, the broodstock of which grows 20% faster than the Turbo broodstock. This line is aimed at production in hyper-intensive production systems where the grow-out time is key to economic profitability. Other lines focus on broodstock that tolerates extremely low salinity environments and on growth without the use of animal protein – the so-called "vegetarian shrimp".

Image: CP Foods (CPF)

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**Thailand (35%), China (30%), Vietnam (20%), and others (15%)**
Number of broodstock supplied to the market	**140,000-171,000**

	2017	2018	2019
Number of broodstock supplied to the market[2]	N/A	N/A	N/A

Export trends explained

CP almost exclusively sells broodstock to its own subsidiaries in Asia and around the world. As a result, the number of broodstock supplied to the market by CP is almost exclusively determined by the performance of its subsidiaries.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources.
[2] As reported to *Shrimp Insights* by the company.

VIETNAM

CP Vietnam Corporation

Under CP Vietnam Corporation, CPF operates shrimp feed mills, farms and hatcheries. With five hatcheries, CP Aquaculture Vietnam has a 15% market share in Vietnam's PL market. This makes CP the second largest player in the PL market in Vietnam, after Viet-Uc.

Type of facility: NBC and BMC
Species: *L. vannamei* and *P. monodon*
Possible export markets:
Only Vietnam

PHILLIPINES

CPF Philippines Corporation

CPF operates three shrimp hatcheries, six commercial shrimp farms and a feed mill under its Philippines subsidiary CPF Philippines Cooperation.[3] This subsidiary imports broodstock from Thailand as well as from the US. In 2019, the company imported 6,608 broodstock, which is almost 35% of the total volume of broodstock imported into the Philippines.

Type of facility: NBC and BMC
Species: *L. vannamei* and *P. monodon*
Possible export markets:
Only Philippines

SRI LANKA

Lotus Aquaculture

In 2019, CP India purchased 75% of the shares of Lotus Aquaculture in Sri Lanka.[4] Lotus Aquaculture operates one *L. vannamei* and one *P. monodon* hatchery, several shrimp farms and a shrimp processing factory. The company is one of two enterprises in Sri Lanka that have been permitted to import *L. vannamei* broodstock.

Type of facility: NBC and BMC
Species: *L. vannamei* and *P. monodon*
Possible export markets:
Only Sri Lanka

INDIA

CP Aquaculture India

In India, CPF operates at least four hatcheries. As Thailand is excluded as a broodstock supplier to India, CP Aquaculture India imports broodstock mainly from Kona Bay in Hawaii.[5] CP Aquaculture India is one of four large players in the hatchery business. Its main competitors are BMR Industries, Vaisakhi Bio Marine and the Sapthagiri group.

Type of facility: BMC
Species: *L. vannamei*
Possible export markets:
Only India

MALAYSIA

CP Malaysia

CPF's hatchery business in Malaysia operates under CP Malaysia's subsidiary Asia Aquaculture Sdn. Bhd. and currently has five hatcheries operational in the country. The company also operates five commercial shrimp farms, a feed mill and a processing plant in Malaysia.

Type of facility: NBC and BMC
Species: *L. vannamei* and *P. monodon*
Possible export markets:
Only Malaysia

US

Homegrown shrimp

In 2019, CPF announced an investment in an RAS farm and a hatchery in the US (now known as Homegrown shrimp).[5] The firm recently stated that more investments in shrimp farms might follow in the future.[6]

Type of facility: BMC
Species: *L. vannamei*
Possible export markets:
Only US

[3] See BFAR: https://www.bfar.da.gov.ph/services?id=773#post.
[4] See https://www.cpfworldwide.com/storage/ir_newsletter/pdf_enM-news0619.pub_1562330393.pdf.
[5] https://www.bangkokpost.com/thailand/pr/1955131/cpf-builds-aquaculture-5-0-shrimp-farm-in-the-usa.
[6] See https://www.bangkokpost.com/business/1872079/cp-considers-setting-up-us-shrimp-farm.

SYAQUA

SyAqua was established in 2001 by US animal genetics company SyGen to develop a genetic improvement program for *L. vannamei*. Founder stocks were developed and NBCs and BMCs were set up in the US and Thailand. In 2009, Gold Coin, a major animal protein producer in Asia, acquired a majority share in SyAqua. Gold Coin fully acquired SyAqua in 2010 and in 2017 the SyAqua shrimp genetics business merged with Gold Coin's hatchery feed business and became Gold Coin Biotechnologies (GCB). Golden Springs Group sold 75% of Gold Coin's feed business to Philippine-based Pilmico in 2018 and the remaining 25% in 2019 and retained full ownership of GCB businesses under the SyAqua brand. With its new CEO Patrick Waty taking over mid-2019, SyAqua aims to become one of the most important players in genetics and hatchery feed for shrimp and tilapia hatcheries in Asia by 2024. To support this ambition, SyAqua has invested in upgrading its facilities around the world. The company is currently investing in a new modern hatchery feed plant which will allow SyAqua to offer a wider range of products and to produce more hatchery feed.

WWW.SYAQUA.COM

owned by

GOLDEN SPRINGS GROUP

Golden Springs Group is an enterprise active in the agriculture and healthcare sectors of emerging markets. Building on rich experience, Golden Springs Group has set out to create a leading business in the sectors of agribusiness and distribution of health care products for animals and humans. Golden Springs Group aquaculture businesses cover hatchery feed, shrimp breeding and genetics, and a global, integrated tilapia business. With a staff of over 10,000, Golden Springs Group is connected to over 50,000 customers who provide food and healthcare products to people in more than 30 countries, every day.

WWW.GOLDENSPRINGSGROUP.COM

Breeding lines

Balanced line

The SyAqua breeding program adopts a "balanced" approach targeting an optimal combination of growth, survival of specific disease challenges, and ability to cope with a wide range of environmental conditions. This allows the development of shrimp lines that show better yield (higher survival) and faster growth under a range of commercial conditions. This is the only line sold to the market.

SyAqua continues to invest in genetics research to diversify its portfolio. It aims to offer resistant lines which can tolerate very challenging conditions at farm level. The launch of the new lines, of which development started in 2016, is expected in early 2021.

SyAqua Americas
In the US, the company runs an NBC and a BMC from where it can export to all markets. Besides its existing breeding program called the "balanced line", the company started a new breeding program to be able to market resistant lines in 2021. SyAqua Americas only obtained approval to export to India early 2020. This will enable SyAqua to offer its clients in India not only its hatchery feeds (SyAqua is one of two hatchery feed market leaders in India), but also its genetics.

Type of facility: NBC and BMC
Species: *L. vannamei*
Capacity in 2019: 80,000
Possible export markets:
All

SyAqua Siam
The breeding program operates both in Thailand and in the US under one commercial line called the "balanced line". SyAqua Siam in Thailand moved into its new broodstock facility in Phuket in 2015. Using the founder stocks from the US, SyAqua Siam operates an independent NBC and an independent BMC. SyAqua Siam sells mainly to China but also to Malaysia and Thailand. Currently, SyAqua's operations in Thailand still account for the largest part of its broodstock business.

Type of facility: NBC, BMC and hatchery
Species: *L. vannamei*
Capacity in 2019: 160,000
Possible export markets:
All except India and Indonesia

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**China (77%), Indonesia (6%), Thailand (6%), Malaysia (6%) and others (5%)**
Number of broodstock supplied to the market	**105,000–128,000**

	2017	2018	2019
Number of broodstock supplied to the market[2]	45,000	105,000	128,000

Export trends explained

SyAqua's increased supply, mainly to China, is a result of the company's recent transformation. At a conference in 2018, the Chinese Academy of Fisheries Sciences announced that SyAqua's market share of imported *L. vannamei* broodstock into China was 12% in 2017. SyAqua has recently received approval to export to India and has increased availability of its genetics in Indonesia. The company is expected to show significant future growth in these markets.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[2] As reported to *Shrimp Insights* by the company.

SyAqua Indonesia
SyAqua invested in Indonesia in 2009 when Gold Coin made its first investment in the company. SyAqua currently operates two hatcheries in West Java with an authorized national quarantine facility. With its operations in the US taking off, SyAqua aims to increase its activities in Indonesia. The company not only supplies its own hatcheries but also supplies other hatcheries with SyAqua genetics through broodstock and nauplii.

Type of facility: Hatchery
Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
Indonesia only

TOP AQUACULTURE TECHNOLOGY

Top Aquaculture Technology started its breeding program in the early 2000s. First supplying only its own hatchery in Thailand, the company soon also developed an export business and within a couple of years it became one of the leading suppliers of F1 *L. vannamei* broodstock to China. Top Aquaculture Technology reportedly also supplies some broodstock to Vietnam.

WWW.TOPAQUATECH.COM

owned by

SUNANTA GROUP (SNT)

Besides Top Aquaculture Technology, the Sunanta Group also owns the Kung Siam hatchery and the S. Sunanta farm. SNT was founded in 1988 when it started to supply inputs to shrimp farmers. Farming activities were started in 2000, whereas the hatchery and breeding program were started a couple years later.

WWW.SUNANTAGROUP.COM

THAILAND

The company runs an NBC, a BMC and a hatchery. The BMC has the capacity to produce around 100,000 broodstock annually. Top Aquaculture Technology owns several shrimp farms with a total of 160 ha and 300 ponds for R&D purposes, but also sells some shrimp to the domestic market in Thailand. The company supplies broodstock to its own hatchery for sales of PL to Thai farmers and exports broodstock mainly to China. Top Aquaculture Technology claims to be one of the largest PL suppliers to the eastern part of Thailand. In China, the company is one of the leading broodstock suppliers.

Type of facility: NBC, BMC, hatchery and farms
Species: *L. vannamei*
Capacity: 100,000
Possible export markets: All except India and Indonesia

Breeding lines

TOP AQUA TECHNOLOGY

Top Aqua Technology has only one breeding line which according to the company balances growth with survival. The company promotes its shrimp broodstock and PL as suited for high-density (>125 PL/m2) production systems.

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**China (90%), Vietnam (2%), and others**
Number of broodstock supplied to the market	**88,000–108,000**

	2017	2018	2019
Number of broodstock supplied to the market[2]	N/A	N/A	N/A

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[2] As reported to *Shrimp Insights* by the company.

VIET-UC SEAFOOD JOINT STOCK COMPANY

Viet-Uc was founded in 2001 by Vietnamese-Australian entrepreneur Mr Van Luong and started in the province of Bình Thuân, the heart of Vietnam's hatchery sector. Since the start of its operations, Viet-Uc has become Vietnam's leading hatchery operator with nine hatcheries across the country and a 25-30% market share. Although it used to depend on broodstock imports from overseas, in 2016, the company partnered with CSIRO from Australia to develop its own breeding program. Currently, Viet-Uc is producing its 11th generation *L. vannamei* and its second generation *P. monodon* broodstock. The company is said to produce around 60,000 broodstock annually and it is making investments to become fully integrated. Its broodstock is only used to supply its own hatcheries. The company does not sell broodstock to other hatcheries. Viet-Uc is one of the pioneers in super-intensive shrimp farming in Vietnam and currently has close to 1,000 ha of super-intensive farms spread over four sites in Bạc Liêu, Bịnh Đinh and Quàng Ninh.[1] Furthermore, Viet-Uc announced an investment in its own processing plant[2] which should be ready by the end of 2020 and which should have the capacity to process all of its own shrimp. The company has been active as an aquafeed producer since 2013. In May 2020, Viet-Uc announced it had signed an MoU with Biomar, a global aquafeed player, to establish a joint venture and to invest in further expanding its aquafeed business.

WWW.VIETUC.COM

VIETNAM

Viet-Uc

Viet-Uc's NBCs and BMCs are located in Ninh Thuận and Bình Thuận in the Mekong Delta.[3] Its breeding program obtained SPF certification by the Vietnamese government in 2017 when it started to supply its own broodstock to its hatcheries. Viet-Uc has a network of nine hatcheries along Vietnam's coastline. Its hatcheries have the capacity to produce around 50 billion PL per year. However, actual production is said to be around 16 billion PL. The company has close to 1,000 ha of super-intensive farms in Bạc Liêu, Bình Định and Quảng Ninh.

Type of facility: Two NBCs, two BMCs and nine hatcheries
Species: *L. vannamei* and *P. monodon*
Capacity in 2019: Unknown
Possible export markets: Only Vietnam

Ninh Thuận

[1] See https://www.undercurrentnews.com/2019/11/28/vietnamese-shrimp-giant-viet-uc-looks-for-investor/.
[2] See https://www.seafoodsource.com/news/processing-equipment/viet-uc-to-build-its-first-shrimp-processing-plant-next-year.
[3] See http://vccinews.com/news/37679/vietnamese-%E2%80%93-australian-prawn-broodstock-excellent-quality-after-10-generations.html.

Bình Thuận

***Shrimp Insights* estimates in 2019**[4]	
Export markets	**Only Vietnam**
Number of broodstock supplied to the market	**54,000-66,000**

	2017	2018	2019
Number of broodstock supplied to the market[5]	N/A	N/A	N/A

Export trends explained

Viet-Uc does not disclose its broodstock production numbers but reportedly produces around 60,000 broodstock annually. It has replaced most of its broodstock imports by its own production. Future growth is only expected if Viet-Uc's hatchery and/or farming business expands further.

[4] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[5] As reported to *Shrimp Insights* by the company.

PRIMO BROODSTOCK USA LLC

In 2011, Primo Broodstock USA LLC (Primo Broodstock) started to import WSSV-tolerant APE broodstock from Ecuador to the US. These broodstock were kept in quarantine at the University of Arizona until they were declared free of disease and SPF and before they could be used in Primo Broodstock's facilities. In 2013 and 2014, the company entered the Mexican, Malaysian and Chinese markets. In 2015, Guangdong Haimao Investment Co. Ltd. (Haimao), a large hatchery operator in China, signed an exclusive strategic cooperation agreement with Primo Broodstock, and started using the brand name PU RUI MO. In 2017, Primo Broodstock was acquired by Haimao and its parent company Ningbo Tech Bank.

WWW.PRIMOBROODSTOCK.COM

owned by

GUANGDONG HAIMAO INVESTMENT CO. LTD.

Haimao is the largest player in the hatchery segment in China. In its facilities across China, the company produced 23 billion PL in 2018 and aimed at increasing its sales to 30 billion PL in 2019. In 2018, the company realized revenues of $14m. Haimao Zongye is a subsidiary of Ningbo Tech Bank, an agro-conglomerate also engaged in shrimp feed production. With the acquisition of Primo Broodstock, the two companies included shrimp genetics in their vertically integrated business set-up.

WWW.ZJHAIMAO.COM

New BMC in Fellsmere

CHINA

Guangdong Haimao Investment Co., Ltd.
Haimao is a group of four subsidiaries that produce shrimp broodstock and PL. Based in Zhanjiang, China's biggest shrimp-producing region, the company is owned by one family, which operates three broodstock facilities, 15 hatcheries and more than 40 nurseries. In 2019, the company imported 50,000-60,000 broodstock from Primo Broodstock. This gives Haimao a market share of 10% of China's total number of imported broodstock.

Type of facility: *Nurseries and hatcheries*

Breeding lines

APE SPF

The company's APE SPF breeding line, originally imported into the US from Ecuador, is a robust animal with high resistance to WSSV.

FLORIDA AND TEXAS, US

Primo Broodstock USA LLC
Primo Broodstock's first facilities were set up in Brookshire, Texas in 2011. Although still in use as one of the company's NBCs, the majority of breeding activities now takes place in Florida. There, the company operates an NBC in Mims and a BMC in Fellsmere. Another BMC in Florida is under construction and is expected to be operational by the end of 2020. The existing BMC in Florida has the capacity to produce 100,000 broodstock. The new BMC will add another 300,000 broodstock to Primo Broodstock's overall capacity.

Type of facility: Two NBCs and three BMCs
Species: *L. vannamei*
Capacity in 2019: 100,000
Possible export markets: China, Vietnam, and Malaysia

Texas NBC and BMC

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**China (90%), Vietnam (5%), and Malaysia (5%)**
Number of broodstock supplied to the market	**43,000-52,000**

	2017	2018	2019
Number of broodstock supplied to the market[2]	20,000	36,000	50,000

Export trends explained

Primo Broodstock went through a transition period since being acquired by Haimao. It has a steady market in China through hatcheries operated by Haimao. The company also aims to grow its exports to Vietnam and Malaysia.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[2] As reported to *Shrimp Insights* by the company.

BLUE GENETICS

Blue Genetics is located in La Paz at the Gulf of Cortes, in Baja California Sur, Mexico. The company was founded in 2013 when Groupe Grimaud and Grupo Mahr partnered up to establish a joint venture and set up a shrimp breeding program. Since its establishment, Blue Genetics has been investing in partnerships, commercial relationships and joint ventures abroad. These investments include a close relationship with Topgen Aquaculture in Thailand and a joint venture with BMR Industries in India. Together with BMR Industries, Blue Genetics is the co-owner of the first privately owned BMC in India.

WWW.BLUE-GENETICS.COM

owned by

GROUPE GRIMAUD

Founded in 1968, Groupe Grimaud has extensive experience in the field of genetic selection, genetic analysis and biopharmacy. It is the world's second largest multi-species breeding company; it has a direct industrial presence in ten countries and is commercially present in more than 100 countries. Its annual revenues are over $350m, and it has over 2,100 employees.[1]

WWW.GRIMAUD.COM/EN

Celebration of the start of the BMR Blue Genetics BMC in India.

Breeding lines

"GROWTH"

The "growth" line is positioned as having a globally competitive growth rate, high productivity in hatcheries and excellent performance in low and high-density systems with different salinity levels.

"RESISTANCE"

The "resistance" line has high resistance to diseases present in farms, robust qualities and satisfactory growth rates in a variety of environments.

[1] See https://www.shrimpnews.com/FreeReportsFolder/NewsReportsFolder/MexicoBlueGeneticsWebpage.html.

Blue Genetics
The NBC and BMC in Mexico are the global headquarters of Blue Genetics. This facility has the capacity to produce 100,000 broodstock annually and, on top of that, can produce an unlimited amount of PPL. From Mexico, Blue Genetics ships its products to its strategic partners in especially India, Thailand and Vietnam.

Type of facility: NBC and BMC
Species: *L. vannamei*
Capacity in 2019: 100,000[2]
Possible export markets: All

BMR Blue Genetics Pvt. Ltd.
The BMR Blue Genetics facility in India has the capacity to produce 80,000 to 90,000 broodstock annually. According to local sources, the facility produced around 25,000-30,000 broodstock in 2019. BMR Industries is a vertically integrated shrimp company owning all parts of the chain: hatcheries, farms, feed mills as well as processing facilities. BMR Industries is among the top four suppliers of PL to the Indian market. The BMC distributes not only to its own hatcheries, but hatcheries, but also to independent hatcheries.

Type of facility: BMC
Species: *L. vannamei*
Capacity in 2019: 80,000-90,000
Possible export markets:
Only India

Topgen Aquaculture
Topgen Aquaculture has its own breeding program and NBC for *P. monodon*. It sells *P. monodon* nauplii and PL under the brand blackGEN. For its *L. vannamei* nauplii and PL, the company has a partnership with Blue Genetics. Blue Genetics ships PPL to Thailand which Topgen will grow into broodstock.

Type of facility: BMC and Hachery
Species: *L. vannamei and P. monodon*
Capacity in 2019: N/A
Possible export markets:
Only Thailand

***Shrimp Insights* estimates in 2019**[3]	
Export markets	**India (82%), Thailand (13%), and others (5%)**[4]
Number of broodstock supplied to the market	**42,000-51,000**

Number of broodstock supplied to the market[5]	**2017**	**2018**	**2019**
	N/A	N/A	N/A

Export trends explained

Blue Genetics sells broodstock to external clients worldwide but also supplies PPL to its partners which run BMCs in India and Thailand. The Shrimp Insights estimate above includes the number of broodstock produced by BMR Blue Genetics in India. The amount of broodstock produced by BMR Blue Genetics is estimated to have been around 25,000 broodstock in 2019.

[2] The company has stated that this number specifically applies to broodstock; it has a capacity to produce a virtually unlimited number of PL.
[3] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[4] Based on 2018 international trade data, including exports of PL and broodstock. The number is based on export value per market.
[5] As reported to *Shrimp Insights* by the company.

SEA PRODUCTS DEVELOPMENT

Sea Products Development (SPD) started its current operation in Texas, the US, in 2010. The company focuses on producing SPF shrimp which are specifically developed for fast growth in intensive grow-out systems. As such, SPD supplies customers in the US and Europe who have indoor intensive shrimp farms, while also increasingly selling broodstock to Asia. In 2017, SPD's facilities in Texas were heavily hit by hurricane Harvey. The company was fortunate that its pure lines were stored in a biosecure building unaffected by the hurricane. Nevertheless, it took till 2018 before broodstock shipments could resume. In October of that year, SPD reported to be shipping PL to companies in Canada and Europe as well as some broodstock to Mexico. In 2019, while shipping broodstock to India, SPD announced it was back in the game. The company used to be part of Global Blue Technologies (GBT), a group focused on intensive indoor shrimp farming, but in 2019 the two companies split up and SPD now operates independently.

WWW.SEAPRODUCTSDEVELOPMENT.COM

Breeding lines

SPD HYBRIDS

SPD's broodstock are specifically developed for production in intensive grow-out systems and combine a focus on growth with a high tolerance for stress and a heavy tail weight.

Sea Products Development
SPD's facilities are located in Texas. The facilities include an NBC, a BMC and a grow-out farm. From its Texas facilities, SPD supplies PL to farmers in the US, Canada and Europe, and broodstock to farmers in Asia and Central America.

Type of facility:
NBC, BMC and grow-out farm
Species: *L. vannamei*
Capacity in 2019: 200,000
Possible export markets: All

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**India (60%), China (35%), and others**
Number of broodstock supplied to the market	**13,000–16,000**

	2017	2018	2019
Number of broodstock supplied to the market [2]	6,000	32,500	52,000

Export trends explained

SPD was hit heavily by hurricane Harvey in 2017 and only started exporting again by the end of 2018. The number of broodstock supplied to the market as reported by SPD includes broodstock for own use and sales within the US. The *Shrimp Insights* estimate of the number of broodstock exported and the export markets in 2019 only refers to *the Shrimp Insights* 2019 estimate and not to the number reported by SPD itself. The company explains that it also exports minor volumes to Mexico, Belize, and Europe.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources. The *Shrimp Insights* estimate only refers to exports.
[2] As reported to *Shrimp Insights* by the company.

GLOBAL GEN INDONESIA

Global Gen Indonesia, also known as PT Bibit Unggul, is the first and only company in Indonesia that operates an SPF certified breeding program. The government of Indonesia approved Global Gen's facilities for SPF breeding in 2008 after its breeding program was tested to be free of OIE-listed pathogens for more than two years. Global Gen's breeding facilities are located on the island of Lombok where it operates its NBC and BMC. The company is also involved in the operations of several shrimp farms and hatcheries in North Sumatra. Global Gen currently has a stake in feed mill PT Intraco Agroindustry and was previously involved in the production of fish, shrimp and poultry feed through PT Universal Agri Bisnisindo,which was sold to Netherlands-based animal protein producer De Heus in 2018. That same year, its breeding facilities were damaged by the earthquake that struck Lombok in August and caused massive damage to the local infrastructure. By mid-2019, Global Gen resumed its SPF broodstock distribution program.

WWW.GLOBALGEN.CO.ID

Breeding lines

HY-G

Global Gen High Growth (HY-G) broodstock are specially selected for excellent growth rates and the broodstock are suitable for intensive shrimp farming operations with strict biosecurity and hatchery management standards.

HY-S

Global Gen High Survival (HY-S) broodstock are specially selected for superior performance, giving good survival and growth rates in commercial farming operations. HY-S broodstock perform well in a wide range of shrimp farming conditions and is a popular choice for hatchery operators.

Global Gen Indonesia (PT Bibit Unggul)
Global Gen Indonesia operates two facilities on Lombok's Northern coast. One facility is the core NBC which also houses a BMC. The other facility, just a few kilometers away, operates as a shadow NBC and another BMC. The company also operates several commercial hatcheries and a demonstration farm in North Sumatra. The demonstration farm operates a highly intensive production system. Since the earthquake in 2018, only one of its facilities on Lombok is operational.

Type of facility: Two NBCs, two BMCs, several commercial hatcheries and several demonstration farms
Species: *L. vannamei*
Capacity in 2019: 80,000
Possible export markets: All

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**Exports (30%), and domestic market (70%)**[2]
Number of broodstock supplied to the market	**12,000–14,000**

	2017	2018	2019
Number of broodstock supplied to the market[3]	24,000	15,000	13,000

Export trends explained

The decline in exports was caused by the fact that the company was heavily hit by the earthquake that struck Lombok in August 2018. The company needed the first half of 2019 to recover but it is hopeful to increase its output back to pre-2018 levels in 2020 and 2021.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources. The *Shrimp Insights* estimate only refers to exports.
[2] This estimate is based on data reported by the company.
[3] As reported to *Shrimp Insights* by the company.

MOLOKAI BROODSTOCK COMPANY

Founded in 1984 and owned by Steve Chaikin, Molokai Broodstock Company (MBC) constitutes the longest running aquaculture operation in Hawaii. The company's facilities are located on the island of Molokai; MBC is the only aquaculture operation on this island with only 7,000 inhabitants. MBC selects the strongest animals from its own ponds and ensures limited inbreeding. MBC exports small numbers of its broodstock, at a cost below the industry average, to various countries around the world.

WWW.BROODSTOCK.COM

Molokai Sea Farms and Keawa Nui Farms
MBC operates two independent broodstock production facilities located on the remote island of Molokai. These two facilities, Molokai Sea Farms and Keawa Nui Farms, both operate as an NBC and BMC and each have their own quarantine facilities.

Type of facility: Two NBCs and two BMCs
Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets: All

Breeding lines

MOLOKAI BROODSTOCK

MBC's broodstock originates from the Oceanic Institutes breeding program and are SPF certified.

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**China (50%), India (30%), others**
Number of broodstock supplied to the market	**9,000–11,000**

	2017	2018	2019
Number of broodstock supplied to the market[2]	N/A	N/A	25,000

Export trends explained

MBC claims to have mainly exported to the Middle East, Korea, the US, China and Vietnam. Part of its exports consists of broodstock but the company also ships PL. The number reported by the company is larger than the number estimated from other data sources.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources and expert opinions.
[2] As reported to *Shrimp Insights* by the company.

OCEANIC INSTITUTE

HAWAI'I PACIFIC UNIVERSITY
Oceanic Institute

Oceanic Institute of Hawaii Pacific University (OI) has a slightly different role in the industry compared to commercial broodstock suppliers. OI is a non-profit, applied aquaculture research and development organization that operates as an independent research unit within Hawaii Pacific University, located in Oahu, Hawaii, US. OI was established in 1962 and its mission is to develop and transfer environmentally responsible technologies to increase aquatic food production while promoting the sustainable use of ocean resources. OI, as part of the US Marine Shrimp Farming Program (USMSFP), was the first organization to develop an SPF population of *L. vannamei* shrimp, the first to initiate a family-based shrimp breeding program, as well as the first to construct and operate a biosecure NBC. The first SPF stocks that were selected for fast growth and resistance to TSV served as founder stocks for many US-based shrimp broodstock suppliers.

In recent years, OI has primarily focused on research and development and technology transfer projects using its selectively bred *L. vannamei* stock, while directly marketing a small quantity of broodstock to companies around the world. OI has managed large projects in several Asian countries. These projects include the development of specialized lines of *L. vannamei* selected for unique conditions/traits and the design, startup and remote management of breeding programs and BMCs. For example, OI assisted the MPEDA RGCA to establish the first BMC in India.

WWW.OCEANICINSTITUTE.ORG

Breeding lines

MULTIPLE

All OI breeding lines are SPF. Breeding lines owned and/or developed by OI are selected for a variety of traits and trait × environment combinations, including growth (multiple harvest sizes and farming conditions/systems), reproductive output, hatchery survival, grow-out survival (multiple farming conditions/systems), and disease resistance (e.g. to TSV, WSSV and AHPNDS). OI typically uses a family-based breeding approach, but the exact breeding program design depends on the specific project. It utilizes molecular markers for pedigree tracking, family assignment, and monitoring of inbreeding and population structure. OI also recently implemented genomic selection for several of its lines.

OI

OI is located on a 23-ha site on the eastern tip of Oahu, Hawaii, US. OI has over 10,000 m2 of roofed laboratory space, multiple tank fields with units with a capacity varying from 1.5 to 30 MT, and several lined ponds. OI operates an NBC capable of producing and evaluating over 300 shrimp families per year, as well as two additional hatcheries on campus that can produce another 400 families per year. OI operates a state-of-the-art molecular genetic laboratory to support its breeding program and international projects.

Type of facility:
NBC and supporting facilities
Species: *L. vannamei*
Capacity in 2019: 100,000
Possible export markets: All

***Shrimp Insights* estimates in 2019**[1]	
Export markets	**North America, Vietnam and other Asian markets**
Number of broodstock supplied to the market	**5,000-6,000**

	2017	**2018**	**2019**
Number of broodstock supplied to the market[2]	N/A	N/A	N/A

Export trends explained

In 2019, 2.7 million shrimp including germplasm were provided to partner organizations, R&D institutions, as well as directly to the industry. The majority of OI's exports consists of germplasm to support its breeding projects. However, small amounts of broodstock are sold as well. Broodstock import data of Vietnam and the Philippines show that OI supplied each country with 4,800 and 500 broodstock, respectively. OI claims to have exported more than 6,000 broodstock in 2019 but declines to provide the exact number. The *Shrimp Insights* estimate should be considered as a minimal estimate.

[1] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources. The *Shrimp Insights* estimate only refers to exports.
[2] As reported to *Shrimp Insights* by the company.

BENCHMARK GENETICS SHRIMP

Benchmark Genetics

In 2016, Benchmark Holding Plc. ventured into shrimp genetics when it invested in CENIACUA's shrimp breeding program in Colombia. This program had been set up in 1997 by the Colombian shrimp sector with government support, under the supervision of Akvaforsk, already a Benchmark company since 2015. Following its acquisition of CENIACUA, Benchmark focused on developing its infrastructure in Florida, US, and on developing commercial breeding lines aimed at the Asian market. Trials were conducted from 2017 onwards and commercial broodstock production in its new facility in Florida started in 2018. In 2019, Benchmark announced a joint venture in Thailand to establish a local BMC. Benchmark strives to be among the three largest shrimp broodstock supplier in the world, hoping to make its shrimp branch as successful as its salmon program.

WWW.SHRIMP.BMKGENETICS.COM

owned by

BENCHMARK HOLDING PLC.

Benchmark Holding Plc. is involved in genetics for most major aquaculture species. Its main revenues in genetics come from salmon, for which it has major investments in Norway, Iceland and Chile. Besides salmon, the company is also a major player in tilapia, and now targets a top position in shrimp. Benchmark's breeding programs are supported by the expertise and technologies developed by its subsidiary Akvaforsk, acquired in 2015. Benchmark is furthermore involved in advanced nutrition. This part of the business is operated by its subsidiary INVE Aquaculture, also acquired in 2015. INVE is world leader in early nutrition and has a strong market position in most of the Asian, European and Latin American markets.

WWW.BENCHMARKPLC.COM

Breeding lines

BMK Protect®

The BMK Protect line is selected for its resistance to WSSV and AHPND/EMS. Commercial trials conducted under harsh and stressful outdoor conditions in China demonstrate the BMK Protect line's growth rate potential with an ADG of 0.18 g per day at 90 days of culture and a density of 70 pieces per m2.

BMKLowSal®

The BMKLowSal line is selected for growth in low salinity. Commercial trials conducted at 3 ppt salinity in outdoor conditions demonstrate the BMKLowSal line's growth rate potential with an ADG of 0.23 g per day at 90 days of culture and a density of 78 pieces per m2.

BMK Yield®

Selected primarily for growth combined with high survival rates.

Benchmark Genetics Colombia
In 2016, Benchmark acquired the aquaculture breeding programs operated by the Center for Aquaculture Research (CENIACUA) in Colombia. The *L. vannamei* breeding program started back in 1997 and was designed and supervised by Akvaforsk Genetics Center for many years. The Colombia facilities include an isolated NBC and a hatchery near Cartagena on the Atlantic Coast, an NBC and hatchery on the Pacific coast and a disease challenge facility in Bogotá.

Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
Thailand, Peru, the US, Spain

Benchmark Genetics USA
Benchmark Genetics USA started its operations in Florida in 2018. It refers to its facility there as an "elite multiplication center". The Florida facility receives grandparent broodstock from its facilities in Colombia that are quarantined and bred for multiple generations to become certified SPF in the US. Commercial production and sales are expected to grow during 2020-2021. Asia is the main market focus of the Florida facility. Vietnam's provincial import data shows that Benchmark exported more than 4,000 broodstock to Vietnam in the first seven months of 2020. Benchmark hopes to obtain approval to export to India in 2020.

Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
All but India

Benchmark Genetics (Thailand) Limited
In 2019, Benchmark signed an agreement with two partners in Thailand to set up a local BMC to produce broodstock from PPL sourced from its facility in Florida. One of these partners is Thai Royal, a local shrimp feed and processing company. Having a BMC in Thailand enables Benchmark to produce broodstock and PL in local farming conditions. The Thai BMC will primarily supply to the Thai market but may also ship to Vietnam and China. Sales are expected to start in 2021-2022.

Species: *L. vannamei*
Capacity in 2019: N/A
Possible export markets:
All but India and Indonesia

***Shrimp Insights* estimates in 2019**	
Export markets	**N/A, as the company only started in 2019**
Number of broodstock supplied to the market	**N/A, as the company only started in 2019**

	2017	2018	2019
Number of broodstock supplied to the market[1]	0	0	0

Export trends explained

Production only started in 2019. The company strives for a global top three position. To realize this, Benchmark needs to reach a production level of 250,000-350,000 broodstock annually. The company has indicated that its facilities are constructed in such a way that they can grow simultaneously with the market. In 2019, the facility in Colombia supplied to the domestic market, Peru and the US. The facility in the US supplied some broodstock and PL to Thailand, Vietnam and China for field testing.

[1] As reported to *Shrimp Insights* by the company.

NORTH AMERICA BROODSTOCK

North America Broodstock (NAB) was founded in 2016 and is headquartered in California. It is the only broodstock supplier in the US with its facilities on the West Coast. While, perhaps surprisingly, its location is far from the ocean, it is close to the Los Angeles Airport to allow quick direct cargo flights worldwide. The breeding lines used by NAB are continuously tested for all OIE-listed pathogens by the University of Arizona and are bred from animals that originated from Ecuador. At the end of 2017, the company obtained an overall export permit from the USDA and approval from the Chinese authorities to export its broodstock to the Chinese market. The company provides PL to North America and Europe and has the ambition to sell broodstock worldwide. Currently, NAB is raising capital[1] to invest in the grow-out phase of its facility in California.

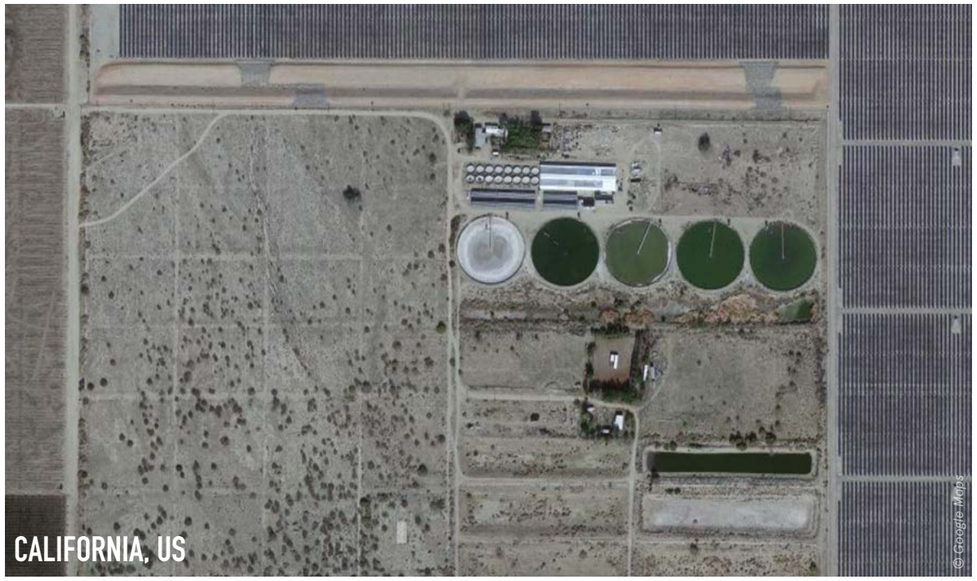
WWW.NORTHAMERICABROODSTOCK.COM

Breeding lines

NBA

NBA's homonymous line of broodstock is based on genetic lines originally sourced from APE lines from Ecuador, now developed into SPT and SPF broodstock.

[1] See https://northamericabroodstock.com/wp-content/uploads/2020/05/North-America-Broodstock-Expanded-Info.pdf.



NAB's NBC and BMC are located in the desert of southern California. It is a biosecure location and the company utilizes pathogen-free water from deep wells. NAB spent the past couple of years setting up the infrastructure and breeding program for its broodstock, the first batch of which went into production at the start of 2020. The facility is currently capable of producing 20,000 broodstock, but the plan is to expand this to 80,000 by 2021. The company produces PL to supply to shrimp farmers in the US and Europe and broodstock for domestic supply in the US and exports to Asia. As the new breeding program only just took off, the company will start supplying broodstock and PL to the market in 2020.

Type of facility:
NBC and supporting facilities
Species: *L. vannamei*
Capacity in 2019: 20,000
Possible export markets:
US and China

***Shrimp Insights* estimates in 2019**[2]	
Export markets	**N/A, as the company only started in 2019**
Number of broodstock supplied to the market	**N/A, as the company only started in 2019**

	2017	2018	2019
Number of broodstock supplied to the market[3]	N/A	N/A	N/A

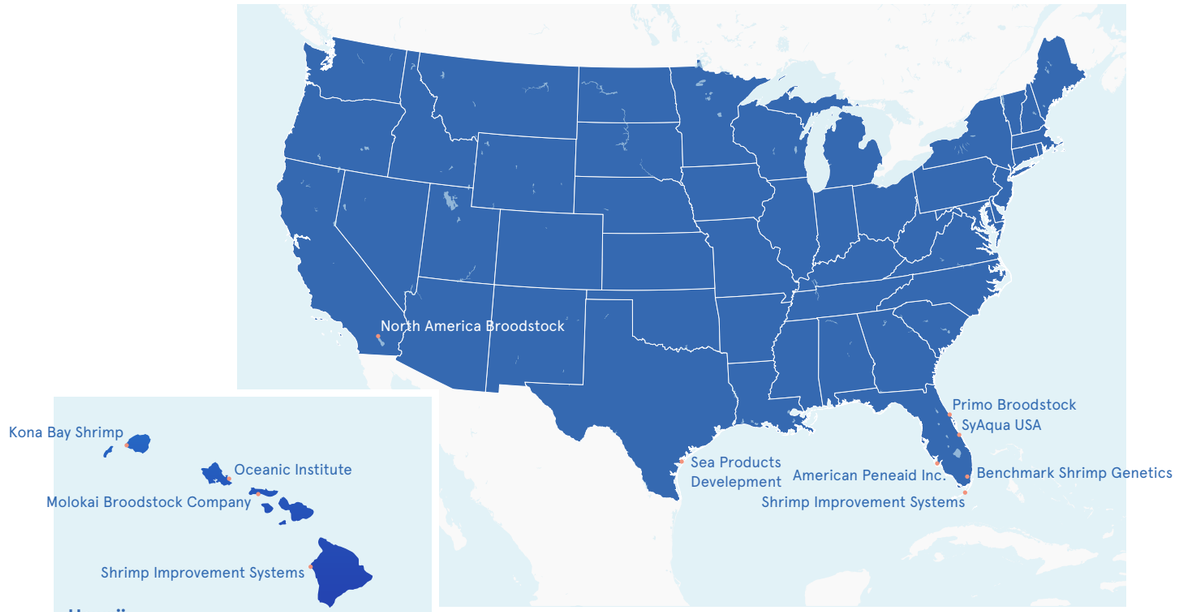
Export trends explained

N/A, as the company only started in 2019.

[2] See Annex 3 for calculation of 2019 estimate. This estimate is not based on official company data but on secondary sources. The *Shrimp Insights* estimate only refers to exports.
[3] As reported to *Shrimp Insights* by the company.

US

In 2019, the two production clusters in the US – (1) Hawaii and (2) Florida and Texas – together supplied about 1 million specific pathogen free (SPF) *L. vannamei*[1] broodstock to the global market. With a value of around $55m, the US broodstock sector alone represented two thirds of the global market.



HAWAII

In the early 1990s, Hawaii succeeded in producing the first *L. vannamei* broodstock. For several decades, the country remained the world's only significant producer of SPF broodstock. Currently, with the rise of other production clusters in the US and in Thailand, that position is under pressure. Nevertheless, being the base of two of the world's top broodstock producers (Kona Bay Shrimp (Kona Bay) and Shrimp Improvement Systems (SIS)), Hawaii will continue to play a crucial role in the future of the *L. vannamei* broodstock business.

In a series of articles published in *Hatchery Feed and Management* in 2019 and 2020, Wyban reveals some of Hawaii's export numbers from 2003 to 2019 (see Figure 1).

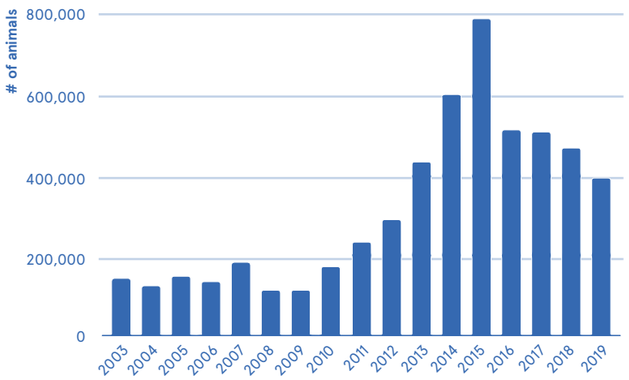
SUMMARY US/HAWAII

Exported: 446,500-602,000
Value $ million: 25-33

SUMMARY US/FLORIDA

Exported: 394,000
Value $ million: 22

FIGURE 1: HAWAII'S BROODSTOCK EXPORTS FROM 2003 TO 2019[2]



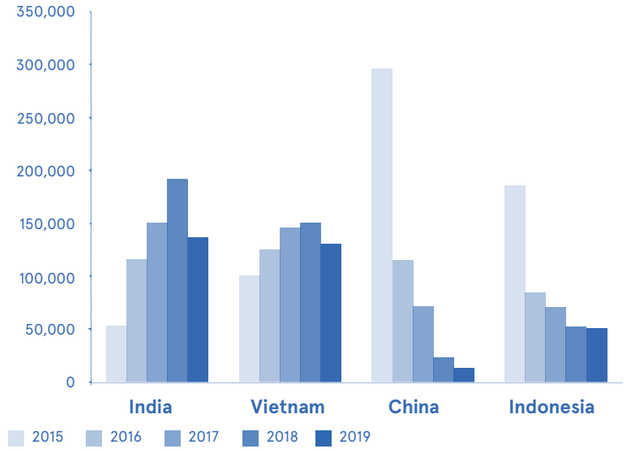
[1] All references are to SPF broodstock, unless specified otherwise.
[2] Source: modified from J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.

Hawaii's exports of broodstock increased rapidly from just over 100,000 broodstock in 2009 to almost 800,000 broodstock in 2015. However, exports started to drop from 2015 to 2016 by almost 300,000 broodstock and then by another 100,000 between 2016 and 2019. In 2019, Hawaii exported just under 400,000 broodstock, worth approximately $22m.

The dramatic drop in exports from 2015 to 2016 was caused by a sudden decline in exports to China and Indonesia. Exports to China dropped from around 300,000 in 2015 to only 15,000 in 2019. Most likely, looking at earlier reports about market shares in China,[3] this drop was mainly accounted for by SIS who earlier owned a significant share of China's imported broodstock market but lost almost its entire market share to other companies (such as American Penaeid Inc. (API) and SyAqua).

Exports to Indonesia also decreased significantly in that same period. In 2015, Hawaii exported around 180,000 broodstock to Indonesia, but this number dropped to around 80,000 in 2016 and gradually declined further to just above 50,000 in 2019. Currently, China and Indonesia no longer serve as Hawaii's largest export markets. India and Vietnam, on the other hand, have shown opposite trends (see Figure 2).

FIGURE 2: HAWAII'S EXPORTS TO INDIA, VIETNAM, CHINA AND INDONESIA FROM 2015 TO 2019[4]



In 2015, Hawaii supplied India with 50,000 broodstock. This number almost quadrupled to 200,000 in 2018, but fell to 140,000 in 2019.[5] Exports from Hawaii to Vietnam followed a similar trend and increased from around 100,000 broodstock in 2015 to 150,000 in 2018 before dropping to around 130,000 animals in 2019. The slight drop in broodstock imports by Vietnam and India in 2019 compared to the previous year may be explained by a weaker shrimp market and less stocking compared to 2018.

The four companies currently operating from Hawaii are Kona Bay, SIS,[7] Molokai Broodstock Company (MBC) and Oceanic Institute (OI) (see the map on page 38 for their location). These four suppliers are among some of the world's first suppliers of SPF broodstock. Their SPF programs are approved and continuously monitored by Hawaii's Department of Agriculture.[7]

According to the *Shrimp Insights* 2020 market study, Kona Bay was Hawaii's largest exporter in 2019. We estimate that the company exported between 180,000 and 220,000 broodstock, constituting 50-55% of Hawaii's total broodstock exports. SIS exported between 160,000 and 200,000 broodstock, and the other producers, OI and MBC, accounted for the remaining 10,000-15,000 exported broodstock.

TEXAS AND FLORIDA

Texas and Florida are home to six *L. vannamei* broodstock producers. The broodstock business in Texas and Florida has developed more recently than that of Hawaii. Hawaii-based SIS and SyAqua have been around since the late 1990s/early 2000s, while Primo Broodstock, Sea Products Development (SPD) and API only started their operations in the last decade. The newest entrant among the US broodstock producers is Benchmark Genetics USA (Benchmark), which started its operations in Florida in 2019. On the West Coast, North American Broodstock (NAB) is another newcomer, having started its activities in the Californian desert in 2016.

[3] See https://www.undercurrentnews.com/2019/05/17/zhuhai-show-chinese-fishmeal-production-in-decline-imports-up/#14037.
[4] Source: modified from J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.
[5] The number reported by Wyban for Hawaii's 2019 exports to India is higher than the number reported by *Aquaculture Spectrum* (2019), which reported a number of 117,000 animals exported to India in 2019.
[6] SIS' operation in Hawaii was previously owned by Jim Wyban, during which period it was known as High Health Aquaculture.
[7] See the State of Hawaii's Animal Industry Division on SPF shrimp broodstock: https://hdoa.hawaii.gov/ai/aquaculture-and-livestock-support-services-branch/spf-shrimp-broodstock/.

According to the *Shrimp Insights* 2020 market study, Florida and Texas exported between 450,000 and 600,000 broodstock, with a value of $25-33m.[9] The biggest producer in 2019 was API, exporting 280,000 to 300,000 broodstock and accounting for 50-60% of all exports from Florida and Texas. API developed its own hybrid genetic lines from Hawaiian SPF broodstock and Ecuadorian all pathogens exposed broodstock. When these were ready for distribution in 2016, its broodstock production soon increased: from around 60,000 in 2017 to around 320,000 in 2019. Today, roughly 90% of API's broodstock is sold to China, where it has rapidly gained market share when the supplies of others to China, especially SIS and CP Foods, decreased.

Other broodstock suppliers in Texas and Florida also sell to China. Primo Broodstock, part of Chinese hatchery company Guangdong Haimao Investment, sells most of its broodstock – about 50,000 animals in 2019 – to China. SyAqua, the second largest supplier of broodstock to China, exports part of its Florida production to China. Altogether, the producers in Florida and Texas exported about 420,000 broodstock to China, constituting about 70% of China's total broodstock imports.

India is the second largest export market for broodstock producers in Texas and Florida. SIS Florida accounts for almost the entire supply to India. According to data published by Aquaculture Spectrum, SIS exported just over 100,000 animals to India in 2019.[10] SPD and API also supplied small volumes to India in 2019 (just over 8,000 broodstock each). Not all US broodstock suppliers were permitted to export to India in 2019 yet. SyAqua only obtained permission this year, and Benchmark's new facility also has not yet been accredited to export to India but is expected to be approved in 2020 or 2021.

TRENDS

- Texas and Florida have become the main production clusters for *L. vannamei* shrimp in the US.
- The share of Hawaii-based suppliers is not expected to decline much further in the next couple of years. Increased production of *L. vannamei* in Asia, especially in India and Indonesia, where other producers face market access challenges, is likely to spark demand for Hawaiian broodstock.
- Production of *L. vannamei* broodstock production in Florida and Texas is expected to continue to grow over the next couple of years. The newly built facilities of Benchmark and Primo Broodstock, and the recently renovated ones of e.g. SPD and SyAqua, combined with the serious ambitions of a company such as API, will surely spark this growth. However, in the long term, if Florida-based suppliers decide to set up broodstock multiplication centers (BMCs).
- If local infrastructure in Asia is developed, broodstock will be produced locally instead of be imported. Hence, increased demand for broodstock will not necessarily lead to increased international trade of broodstock. For example, if Hawaii-based suppliers set up BMCs closer to shrimp farms in Asia, the number of broodstock exported from Hawaii may decline in the long term as the operations in Hawaii will then only supply parent broodstock or parent post-larvae to the facilities in Asia where they will be multiplied to commercial broodstock.

[9] The range is large because SIS and SyAqua have not shared a breakdown in exports between their facilities in Florida, Hawaii and Singapore, and Florida and Thailand, respectively. The minimum of the range is based on the assumption that 25% of their exports originate from Florida while the maximum is based on the assumption that 75% of their exports originate from Florida.

[10] *Aquaculture Spectrum* (2020), Vol. 3, Issue 5.

THAILAND

All the data presented in this country profile on Thailand are based on international trade data, results from the *Shrimp Insights* market study and data obtained through interviews with local industry stakeholders.

IMPORTS AMOUNT TO ONLY AROUND 16,000 BROODSTOCK

Imports amount to only around 16,000 broodstock

The value of Thailand's specific pathogen free (SPF) *L. vannamei* broodstock imports increased from $623,000 in 2017 to $1.2m in 2018 and remained at a similar level, at $1.1m, in 2019. A small portion of broodstock supplies originates from Mexico. Supplies from Mexico likely mainly consist of parent post-larvae supplied from the Blue Genetics facilities in Mexico to Top Aquaculture Technology, its local partner in Thailand. Exports from Mexico valued $143,000.

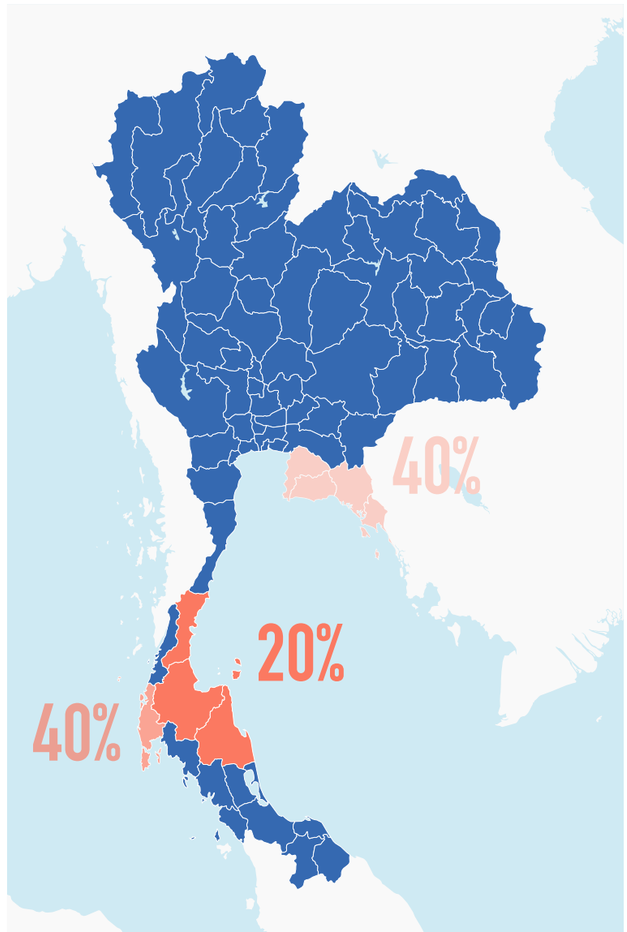
In 2019, a small amount of broodstock was supplied from Singapore ($126,000). The remainder, valued at $865,000, originated from the US. The largest part of these US supplies, probably around two thirds, came from Hawaii and the remainder from Florida. With an average value of $55 per animal, we estimate Thailand's broodstock imports in 2019 to have been around 16,000.

A somewhat outdated list published online by the Department of Fisheries (DOF) includes 15 companies approved for broodstock exports to Thailand.[1] Most major suppliers are included on this list but some newer and smaller players such as American Penaeid Inc. (API) and Sea Products Development (SPD) are missing. Another list by the DOF includes around 15 companies that are approved for imports of *L. vannamei* broodstock.[2] Avanti, with four hatcheries but no breeding program of its own, is expected to be the largest broodstock importer.

SUMMARY

Local production: 65,000-80,000
Imported: 19,000-23,000
Exported: 231,000-320,000
Value $ million: 17-23

PL PRODUCTION IN THAILAND



Source: Estimation by industry sources in Thailand

[1] See https://www4.fisheries.go.th/local/index.php/main/view_blog2/176/11702/504.

[2] Source: modified from J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.

THE LOCAL MARKET REQUIRED AROUND 100,000 BROODSTOCK IN 2019

Thailand produces most of its broodstock domestically. With *L. vannamei* shrimp production in 2019 at around 300,000, according to local industry sources, Thai hatcheries would have required around 90,000-100,000 broodstock. As broodstock imports only were around 20,000, we can assume that around 80,000 were locally produced.

The first company to set up its NBC in Thailand was CP Foods (CPF). CPF currently operates three nucleus breeding centers (NBCs) and breeding multiplication centers (BMCs) supplying broodstock to its hatcheries in Thailand and its subsidiaries in among others China, Malaysia, the Philippines and Vietnam. While CPF previously also sold on the open market and in China, it currently exclusively supplies to its own subsidiaries. With 50% of Thailand's post-larvae market and all broodstock being supplied from its own BMCs, CPF is expected to have produced around 50,000-55,000 broodstock for the Thai market in 2019.

SyAqua and Top Aquaculture Technology have also developed their own breeding programs in Thailand. SyAqua started in Thailand in 2003 when it leased two hatcheries and established its own NBC not long after that. In 2015, SyAqua moved its operations to Phuket. Top Aquaculture Technology has been active in Thailand's shrimp industry since the 1990s. It started its own farming and hatchery operations in the early 2000s and has more recently established its own NBC and BMC. Both companies supply their own hatcheries in Thailand and further produce broodstock for export.

Besides those companies with their own NBCs, several other companies are planning to set up BMCs. Benchmark Genetics USA (Benchmark), for example, in 2019 announced its investment in a BMC in Thailand. Benchmark engaged in a joint venture with Thai Royal, a major shrimp feed producer and shrimp processor and exporter.

Most of the genetics infrastructure in Thailand was already established before the industry collapsed and shrimp production halved due to the EMS outbreak in 2014. As a result, the local production capacity exceeds domestic demand and local broodstock producers like CPF, SyAqua and Top Aquaculture Technology mainly supply to the export market.

THREE MAJOR EXPORTERS OPERATE FROM THAILAND

Thailand-based broodstock exporters are not approved to sell their broodstock to India and Indonesia. Authorities in both countries banned imports from Thailand due to its EMS crisis. Therefore, Thailand-based suppliers export to China, Vietnam, Malaysia, the Philippines and some other smaller markets.

CPF supplies broodstock to its subsidiaries across Asia. Based on official data reported from Vietnam and the Philippines and estimates for its exports to China, Malaysia and other smaller destinations, CPF is assumed to have exported around 90,000-110,000 broodstock in 2019. Top Aquaculture Technology reportedly supplied 100,000 broodstock to China and smaller amounts to Vietnam. Its total exports in 2019 were estimated to be in the same range as those of CPF. SyAqua reported a global sales number of 128,000 broodstock. Assuming that 50-75% originated from Thailand, the company exported 64,000-96,000 broodstock.

Combining all these figures, we estimate that Thailand exported around 250,000-280,000 broodstock in 2019. Based on the value of Thailand's broodstock exports as reported in international trade data, one would arrive at a similar figure. Thailand's SPF *L. vannamei* broodstock exports in 2019 valued $13m, which equals around 240,000 broodstock.

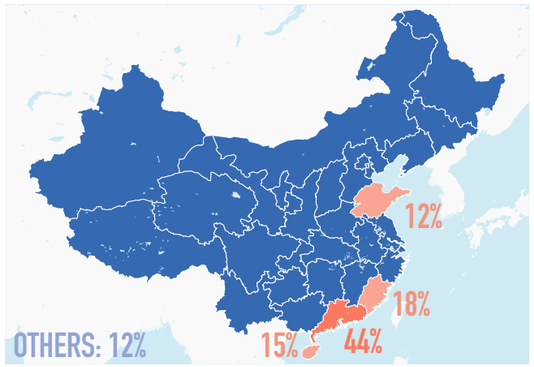
TRENDS

- Thailand's exporters play an important role in the broodstock market in China, Malaysia, the Philippines and Vietnam. Further expansion is restricted by import bans in India and Indonesia. While CPF's growth is linked to its subsidiaries, Top Aquaculture Technology and SyAqua are actively increasing their sales on the open market.
- Thailand has plenty of infrastructure for breeding, including several NBCs and BMCs. At least one new investment has been recently made by Benchmark. Local broodstock production capacity is large enough to meet an increase in demand.

CHINA

All the data presented in this country profile on China are based on international trade data obtained from ITC Trademap, broodstock export data from Hawaii, data obtained from several broodstock companies selling to China, and data obtained from industry experts in China.

L. VANNAMEI PL PRODUCTION IN 2019



Source: China Fishery Statistical Yearbook 2019

SUMMARY

Local production: 54,000-66,000
Imported: 536,000-656,000
Value $ million: 32-40

BROODSTOCK IMPORTS POSSIBLY AMOUNT TO 600,000

According to an estimate presented at China's second National Shrimp Seeds Summit Forum in Guangdong in December 2019, SPF *L. vannamei* broodstock[1] imports in 2019 may have amounted to 600,000.[2] Industry sources claim that local broodstock production of F2, F3 and locally produced F1 *L. vannamei* broodstock accounts for another 400,000. This would put China's total broodstock market at around 1 million in 2019.

China's broodstock requirement is relatively large compared to other Asian countries, as China struggles with several diseases severely impacting survival rates in shrimp hatcheries and farms.[3] Due to the high mortality rate, hatcheries need more broodstock to produce the same amount of post-larvae (PL), while farmers need more PL to produce the same amount of adult shrimp for harvest.

One of the challenges for pinning down the exact number of broodstock imports is that trade data are not adequate. Trade data suggest that in 2019 China imported around $15m worth of *L. vannamei* broodstock. With broodstock having an average value of $55 this would amount to around 266,000 broodstock. However, several industry sources say that a large part of China's imported broodstock is shipped into the country through unofficial routes and that actual broodstock purchases in China amount to $30m or roughly 600,000 broodstock annually.

To avoid import tax, broodstock is smuggled from Hong Kong, sometimes through Vietnam, into mainland China. Imports of broodstock into Hong Kong from the US and Thailand reported in trade data amounted to 75,000 broodstock in 2019. This would increase China's total imports to around 340,000 broodstock, still leaving around 260,000 broodstock unaccounted for. It is assumed that the remaining broodstock is imported into the country as shrimp for consumption instead of for breeding and as such is not included in broodstock trade data.

In March 2020, Undercurrent News reported that Chinese authorities arrested a smuggling ring for illegally shipping 1,600 broodstock across China's border,[4] making this ring being accused of smuggling 46,000 broodstock over the last couple of years.

[1] All references are to SPF broodstock, unless specified otherwise.
[2] See https://dy.163.com/article/EVN8GTLG0514D0GJ.html.
[3] See https://www.undercurrentnews.com/2020/05/08/chinese-scientists-confirm-new-virus-causes-shrimp-glass-post-larvae/.
[4] See https://www.undercurrentnews.com/2020/05/15/chinese-customs-seize-1600-smuggled-shrimp-broodstock/.

API: CHINA'S DOMINANT *L. VANNAMEI* BROODSTOCK SUPPLIER

While in 2017 Shrimp Improvement Systems (SIS) accounted for more than 45% of imported broodstock, in 2019 its market share dropped to below 5%. This is represented by a drop of imports from Hawaii which declined from around 300,000 broodstock in 2015 to only 15,000 broodstock in 2019.[5] CP Foods (CPF), previously selling on the open market, saw its market share shrink to about 10% since in 2017 it decided to sell to its own subsidiaries only.[6]

While SIS almost lost its entire share in the Chinese market, American Penaeid Inc. (API) increased its market presence rapidly from 14% in 2017 to around 45% in 2019. API's broodstock originates from Ecuadorian all pathogens exposed breeding lines and is believed to be more disease tolerant than other broodstock. With the high degree of disease prevalence, API has become the preferred supplier for many Chinese hatcheries.

In 2019, SyAqua and Top Aquaculture Technology (each accounting for about 15% of imports), and Primo Broodstock (accounting for roughly 9% of imports) were the other large suppliers. SyAqua and Top Aquaculture Technology sell their broodstock on the open market. Primo Broodstock is owned by Chinese hatchery group Guangdong Haimao Investment Co. Ltd. (Haimao) and exclusively supplies broodstock to Haimao's hatcheries.

AQUAFEED COMPANIES INTEGRATE BREEDING AND INCREASE MARKET SHARE

China's broodstock imports are concentrated in the southern provinces of Guangdong, Fujian and Hainan. Although hatchery operators have been expanding to the northern provinces where shrimp farming has been increasing, broodstock is normally first imported into the south and then distributed to the north. More than 3,000 *L. vannamei* hatcheries are located throughout the country, mainly in the southern provinces.

Although China's PL sales are still fragmented, broodstock imports are relatively concentrated and in the hands of large pure play hatchery operators and breeding divisions of larger aquaculture and animal feed conglomerates.[7] The most notable integrated feed players with their own hatchery operations and even their own overseas breeding programs are Haimao (part of feed company Ningbo Tech-Bank) and CP China. Other large feed players and integrated aquaculture companies importing broodstock from independent suppliers such as API and SyAqua are the breeding divisions of Tongwei (Hainan Haiyi), Guangdong Haid (Guandong Haixingnong) and Guangdong Evergreen.

MIXED RESULTS IN LOCAL BREEDING PROGRAMS

The Chinese government encourages aquaculture companies to develop their own breeding programs in order to gain more control over broodstock supply.

Many companies in China already have their own breeding programs, often developed with a mix of imported and locally collected broodstock. Before they can be sold on the local market, locally produced genetic lines need to be approved by the government. Examples of local breeding lines sold on the market are Haixingnong 2 (developed by the Yellow Sea Fisheries Research Institute and Guangdong Haid), Xinghai No. 1 (developed by Sun Yat-Sen University and Guangdong Evergreen)[8] and Zhengjinyang No. 1 (developed by Guangdong Ocean University and Zhanjiang Guoxing Aquatic Products Technology).[9]

The success of these locally produced shrimp varieties differs widely, but altogether they are believed to have accounted for around 400,000 broodstock in 2019.[10]

TRENDS

- API has taken over the majority share of the Chinese market for imported broodstock, mainly because of the robustness of the API broodstock and its relatively high survival rates in hatcheries and grow-out systems in China. With high disease prevalence in China, companies producing the most disease-tolerant broodstock will be able to increase their market share in the next couple of years.
- Large integrated feed and aquaculture companies are expected to expand their market share at the cost of smaller pure play hatchery operators. Looking at the size and investment capacity of large integrated feed and aquaculture companies, they will possibly consider investing more in their own breeding programs in China or in acquiring genetics companies abroad. This could reduce demand for imported broodstock.

[5] J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.
[6] See https://www.undercurrentnews.com/2017/03/15/imported-broodstock-no-panacea-for-chinas-shrimp-problems/.
[7] The full list of hatcheries approved for import of broodstock can be found here: http://www.moa.gov.cn/jggk/getOpenInfo02%3Fpage%3D8%26code%3D0628&prev=search&pto=aue.
[8] See http://dara.gd.gov.cn/szdpz/content/post_2994106.html.
[9] See http://dara.gd.gov.cn/szdpz/content/post_2998202.html.
[10] A brief description of some of the local breeding programs can be found here: https://news.tianyancha.com/ll_6bb0whpxro.html.

API High Vigor®
Takes the Industry by Storm

www.penaeid.com

American Penaeid, Inc. (API) is a Florida, USA based shrimp genetics and broodstock company. Founded in 2016, the company is a newcomer to the field of shrimp genetics. Yet even though only a few years old, API has quickly raised the bar for the shrimp genetics industry and became one of the fastest growing shrimp genetics companies in the world. Its success and growth are based on the performance of their API High Vigor® stocks which have been making a real positive impact for shrimp farmers around the world.

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API was created out of necessity by its parent shrimp farming company, American Mariculture (AMI). For several years, AMI suffered declining survival using standard available broodstock. The company learned the hard way the importance of having high quality optimized and strong genetics. With the development of API's High Vigor® stocks, AMI was once again able to grow shrimp profitably, and soon, when the rest of the world learned about the amazing performance of API's stocks, farmers everywhere wanted to use them. API's growth is based on word of mouth and actual performance.

Shrimp farming is very hard and if farmers do not use the best performing shrimp who are adapted to thrive in the farm's actual conditions, it becomes almost impossible to grow productive crops. Shrimp farmers face ever changing environments, changing diseases, changing markets and they need to stock their ponds with shrimp they can depend on.

For many years, the shrimp genetics industry focused solely on growth rates. Farmers were told that only faster and faster growing shrimp would lead to success. While everyone loves fast growing shrimp, a farmer makes money on the number of kilos he harvests. Growth is good, but not at the expense of survival. Fast growth was also promoted as a solution to combat disease, the thinking went that if the shrimp were going to die of disease anyway, better that they grow fast. So, when a pond would get hit with mortality due to disease, and the farmer ordered an emergency harvest, hopefully the shrimp were large. Over time this fast growth formula failed, as farmers lost more and more money due to unproductive crops. Farmers started looking at growing other crops, or just not stocking, affecting all other industries that relied on shrimp production.

When calculating shrimp farming projections, survival is the most important factor in determining profitability. When comparing two farmers where the first farmer is given a fast-growing shrimp that has a high chance of mortality, and the second farmer stocks a normal growing shrimp that is strong and has the ability to survive, it is the second farmer who can actually harvest and sell shrimp. The first farmer only fed the fast-growing shrimp and has nothing to show for it. It was time for a new approach and API led the way. Today shrimp farmers around the world stock and continue to re-stock their ponds with API shrimp.
API's success is no accident. The company developed and implemented a completely novel genetic selection program using high through-put DNA sequencing systems. In just a few years, API has created very strong and hardy productive shrimp that have allowed many farmers around the world to grow profitable crops again. The API genetic selection program novel genetic selection technique has the following four main attributes:

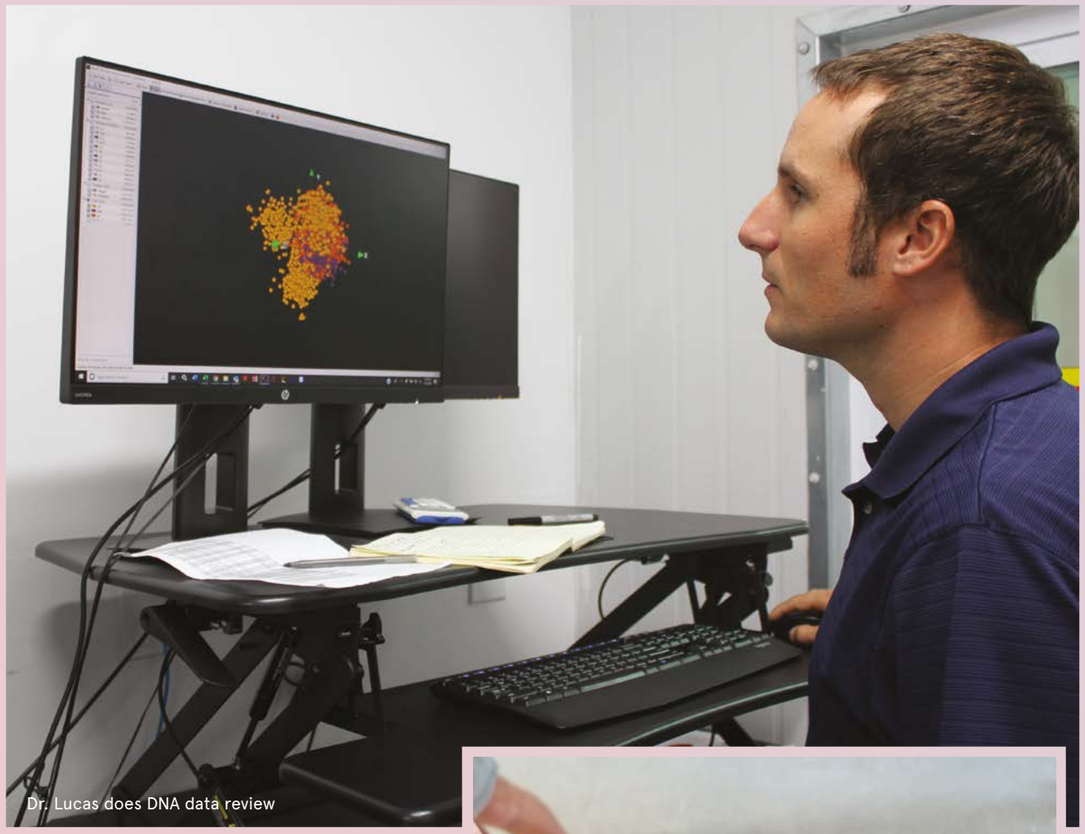
1. Survival first, growth second. API selects families that show high survival in various environments, and then chooses faster growing shrimp

Thousands of DNA samples ready for analysis

within these high survival families, API can maintain very high survival rates generation after generation while improving growth rates. This new strategy is producing shrimp that are simply better able to adapt to the various challenges faced by shrimp farmers everywhere. Strong and super healthy, the API High Vigor® shrimp can withstand stressful and challenging environments that farmers face every day.
2. Using DNA fingerprinting, API can monitor the genetic distance between crosses. By maintaining a high distance, we improve Hybrid Vigor®.
3. The DNA identification technology allows API to find out exactly which shrimp crosses perform best in actual production grow-out environments when they are stocked alongside many other shrimp crosses. Once the DNA profile of the best performing shrimp cross at the actual farm level is identified, API selects DNA matched shrimp in its nucleus breeding center to replicate the best performing cross.
4. By unlocking the DNA of each shrimp, API can select down to a specific animal and instead of inbreeding, it is able to outbreed our populations.

In 2019 API spent over $1 million on building its own High Throughput Genetic DNA Lab. The lab allows it to genetically DNA fingerprint up to 10,000 individual shrimp every day. Dr. Mitch Lucas is API's genetic program director and he oversees all aspects of our genetic program. The lab uses state of the art equipment that allows its genetics team to rapidly identify the DNA profile of every shrimp they are testing and compare that profile to many others. By then combining individual weights and other qualitative factors, the lab can quickly learn which shrimp crosses are the best for a given environment.

In addition to the lab, API operates its own hatchery, growout and shipping centers. The company employs 75 full time persons and has recently improved its annual broodstock capacity to 1 million pairs per year. API's broodstock team is headed by Mrs. Margaret Barlow who oversees all aspects of the selection, packing and logistics. Under Mrs. Barlow's leadership, API has a daily broodstock shipping capacity of up to 8,000 pieces. The company's location on the West Coast of Florida gives it access to 4 international airports within 3 hours from the broodstock shipping center.



Dr. Lucas does DNA data review

API does not take its success for granted. The company is making the investments and commitments to continue improving and optimizing its stocks to ensure that farmers and its parent company continue to obtain highly productive crops. Only when farmers are successful are all the other parties of the interconnected shrimp industry able to thrive.

Every year API's broodstock performance has improved. Year after year more and more hatcheries are choosing API broodstock as shrimp farmers gain experience with High Vigor® PL's produced from its broodstock. In addition to offering broodstock, the company works closely with its customers on custom genetic programs that help create custom lines of breeders with specific performance traits that are required by certain farmers for their specific environment and systems.

For too long shrimp farmers used animals solely bred for faster growth. This could work if all farmers had similar environments and systems. The reality is that shrimp farmers grow shrimp in many types of systems and all different kinds of environments. High/Low salinity, high/low temperature, water exchange, bio-floc or RAS, high density, or low density. On top of that there are always disease and vibrio concerns. To assume that one shrimp could be great for all these different systems and environments is just not credible. API's approach of using High Vigor® shrimp who are very hardy will give farmers a chance today, but in the coming years, using its DNA based selection techniques and actual production data from various environments, the company plans to offer many more varieties to meet farmers ever changing needs and conditions.

As part of its industry leadership position, API is proud to sponsor this *Shrimp Insights Report Series* SPF L. vannamei *Broodstock report.* The shrimp industry has tremendous potential and only by giving all stakeholders access to the data can the industry grow and prosper. API salutes everyone involved in the shrimp farming industry.

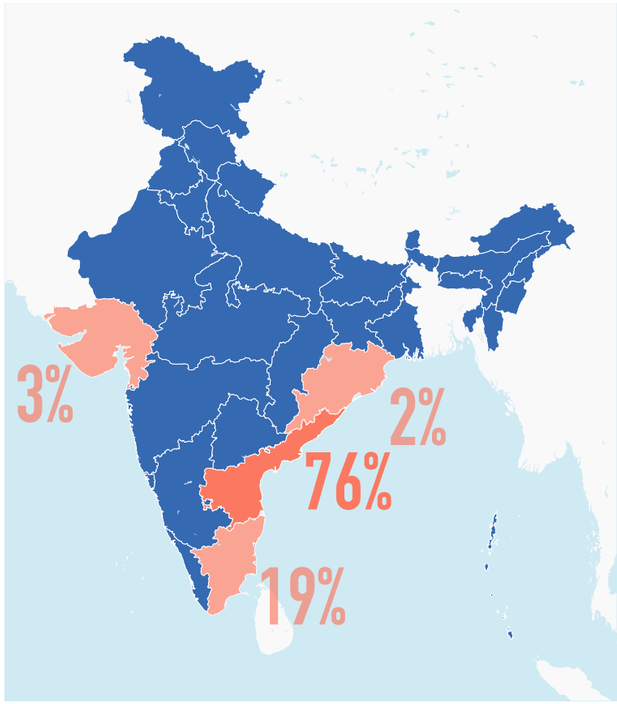
INDIA

All data presented in this country profile are derived from data published by the Coastal Aquaculture Authority (CAA) and Rajiv Gandhi Centre for Aquaculture (RGCA) on a monthly basis in the Indian *Aquaculture Spectrum* magazine.

SUMMARY

Local production: 32,000-40,000
Imported: 233,000
Value $ million: 15

APPROVED CAPACITY FOR BROODSTOCK BY CAA



Source: Coastal Aqualculture Authority 2020

2019 BROODSTOCK IMPORTS AT ALMOST 235,000

In 2019, India imported 233,425 broodstock[1]. This was slightly less than in 2018 when the country imported 254,270 broodstock. The decline in imports was due to the fact that farmers were hesitant to stock early and collectively in 2019 as had been the case in 2018 – in April 2018, prices crashed. In 2019, stocking therefore happened later than normal and was spread across several months to mitigate the risk of a price crash collectively affecting farmers' first crops. Although production caught up towards the end of the year, overall stocking in 2019 was slightly down compared to 2018 resulting in lower broodstock imports. Local broodstock production in 2019 was as follows: RGCA produced 11,000 broodstock and BMR Blue Genetics produced between 25,000-30,000 broodstock. Imports and local production combined, India used somewhere between 269,000 and 274,000 broodstock in 2019.

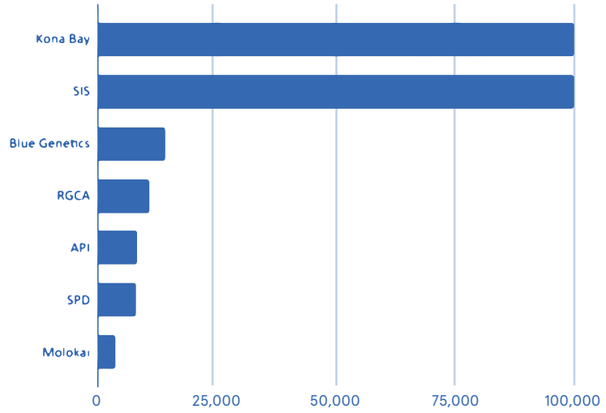
KONA BAY AND SIS: THE LARGEST SUPPLIERS OF BROODSTOCK IN 2019

Currently, the CAA has approved 13 *L. vannamei* and 2 *P. monodon* broodstock suppliers.[2] The last company that obtained a permit to export to India was SyAqua Americas in January 2020. Thai suppliers are banned from supplying broodstock due to the prevalence of EMS in Thailand.

Kona Bay Shrimp (Kona Bay) and Shrimp Improvement Systems (SIS) dominated the market in 2019. Both companies supplied around 100,000 broodstock. Jointly, SIS and Kona Bay accounted for 86% of imported broodstock in 2019. Other international suppliers active in 2019 were Blue Genetics, American Penaeid Inc. (API), Sea Products Development (SPD) and Molokai Broodstock Company (MBC). RGCA, a local government-owned and government-operated BMC, also produced just over 11,000 broodstock in 2019 (see further in this country profile for more discussion on RGCA).

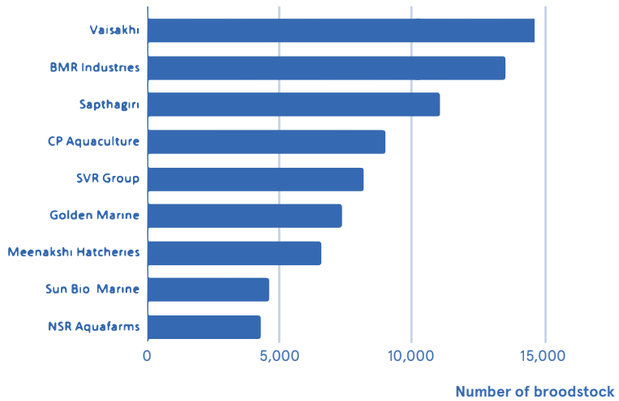
1 The numbers reported by *Aquaculture Spectrum* represent the net count of broodstock. This data may therefore not be entirely in line with data reported in this *Shrimp Insights Broodstock Report* concerning, for example, Hawaii, which may represent gross counts.
2 See CAA, *Empanelment of Overseas Suppliers of SPF Shrimp Broodstock* (17 February 2020), http://caa.gov.in/uploaded/doc/Overseas_suppliers_of_SPF_Shrimp_Broodstock.pdf.

FIGURE 1: MAIN BROODSTOCK SUPPLIERS TO THE INDIAN MARKET IN 2019[3]



Blue Genetics did not only supply broodstock to India but also supplied PPL to its BMC under a joint venture with BMR Industries called "BMR Blue Genetics Pvt. Ltd." Local industry representatives estimate that in 2019 this BMC produced anywhere between 10,000 and 25,000 broodstock. With broodstock capacity of this BMC at around 80,000 annually, it is expected that BMR Blue Genetics will increase their output in 2020 and beyond.

FIGURE 2: INDIA'S TOP 10 F1 SPECIFIC PATHOGEN FREE *L. VANNAMEI* BROODSTOCK BUYERS IN 2019[5, 6, 7]



TOP 10 BROODSTOCK BUYERS: 40% OF TOTAL BROODSTOCK PURCHASES

There are 311 hatchery facilities accredited for imports of broodstock.[4] 140 of these facilities – belonging to somewhere between 120 to130 companies – imported broodstock in 2019. In 2019, the hatcheries jointly imported 334 batches totalling 234,000 broodstock. Eleven hatcheries bought broodstock locally from RGCA.

Vaisakhi is India's largest importer of broodstock importing almost 15,000 broodstock and buying more than 1,000 from RGCA in 2019. The company plans to increase its imports further as it has finished the construction of a new hatchery facility. With its new hatchery, the company's demand for broodstock will increase. In addition to its hatchery business, Vaisakhi is one of the largest corporate farmers in India and is planning to expand into processing soon.

BMR, the second largest importer in 2019, imported just over 13,000 broodstock. As previously mentioned, BMR also operates its own BMC for which it imports parent post-larvae (PPL) from Blue Genetics in Mexico. With anywhere between 10,000 and 25,000 broodstock produced in its BMC in 2019, BMR is an important player as a domestic supplier of broodstock. Its broodstock production capacity is 80,000 broodstock annually and it is likely that the company's production will increase over the next couple of years.

Sapthagiri Group was the third largest importer of broodstock. Sapthagiri Group has grown rapidly by acquiring or leasing one hatchery after another, and, according to local sources, it currently runs around 15 to 20 hatcheries. (Note that some industry players will challenge this number as some of the relationships are of a more "informal" nature and should not be considered to be part of Sapthagiri Group as such.)

[3] See *Aquaculture Spectrum*. These numbers include local production by RGCA but exclude local production by BMR Blue Genetics, as these are not officially reported.
[4] See CAA, *List of Registered Hatcheries for Import of* SPF L. Vannamei *Broodstock For Seed Production,* http://caa.gov.in/uploaded/doc/LIST_OF_REGISTERED_HATCHERIES_11-01-2019.pdf
[5] See *Aquaculture Spectrum*.
[6] Srinidi Biotechnologies is confirmed to be under the SVR Group and is therefore included as such in Figure 2. Prince Aqua and Makineedi hatcheries are identified by some sources to be part of SVR Group but cannot be confirmed by other sources. They are therefore not included under SVR Group in Figure 2.
[7] Sapthagiri Hatcheries, Srinivasa Aqua Hatcheries, Srinivasa Hatcheries, Venkata Sai Hatcheries and Venkatasai Hatcheries are confirmed to be part of Sapthagiri Group and are therefore included in Figure 2. Other hatcheries identified by some but not confirmed by others are: Venkateshwara Shrimp Hatcheries, Venkata Sudha Hatcheries, Sri Puri Jaganadh Hatchery, Sree Kamadhenu Aquatech, Om Maritech and DSR Hatcheries. These are excluded from the Sapthagiri Group in Figure 2.

CP Aquaculture India was the fourth largest buyer of broodstock. Although the company only imported 3,600 broodstock, it was also the largest buyer from the RGCA BMC, buying 5,200 broodstock in 2019. CP Aquaculture's total amount of broodstock used in 2019 amounts to almost 9,000.

LOCAL BROODSTOCK PRODUCTION CAPACITY ON THE RISE

There are two broodstock multiplication centers (BMCs) in India. The first BMC was constructed by RGCA, an agency operating under the Marine Product Export Development Authority (MPEDA). The MPEDA has the vision that India should become less dependent on imported broodstock and the first step in this endeavour was to establish a local BMC. The BMC owned and operated by RGCA was constructed in Andhra Pradesh and began its operations in 2012. Initially, the BMC was supplied by PPL sourced from Oceanic Institute in Hawaii. In 2020, RGCA contracted a partner that would support the establishment of India's first nucleus breeding center (NBC).[8] The NBC should be able to provide the local BMC owned by RGCA with 120,000 PPL from which the BMC would be able to produce a minimum of 60,000 broodstock annually. The company awarded with the contract is responsible for guiding RGCA in the development of the NBC and supplying the founder families for the new breeding program. For as long as the NBC cannot produce 120,000 PPL annually, the selected partner will be required to supply the shortfall from its own supply to ensure that the BMC can operate at capacity.

The second BMC is owned and operated by BMR Blue Genetics and is the first privately owned BMC in India. It began operations in 2019 and has the capacity to produce 80,000 broodstock annually. Collectively, the two BMCs (that owned and operated by RGCA and the one owned by BMR Blue Genetics) now have the capacity to produce around 140,000 broodstock annually.

TRENDS

- Indian shrimp exporters have the ambition to increase farmed shrimp output from 600,000-700,000 MT in 2019 to 1m MT over the next couple of years. This has led to an increase in broodstock demand from 234,000-260,000 MT of broodstock in 2019 to 400,000-450,000 MT of broodstock over the next couple of years.
- Locally produced broodstock will compete with imported broodstock. However, with the current local production capacity and the foreseen increase in overall demand for broodstock, it is likely that the amount of imported broodstock will remain stable or even slightly grow.
- Feed manufacturers and shrimp exports integrate post-larvae (PL) production in their supply chain and service portfolio in order to gain loyalty among farmers and distributors. Examples of companies with PL production integrated in their supply chain are Growel, Avanti Feeds, Devi Seafoods, Apex Frozen Foods and Sai Marine.
- Consolidation in the hatchery segment is foreseen. In recent years, groups like Sapthagiri and SVR have been acquiring smaller hatcheries and are gaining market share. The number of companies importing broodstock is likely to decline but the amount each group imports is likely to increase.

[8] See RGCA, *Request for Proposal, Volume II: Technical Services Agreement for Strategic Partner –Nucleus Breeding Centre (NBC) for* L. vannamei *at Kanyakumari* (December 2019), http://www.rgca.org.in/Tenders/2019_11_27%20Vol%20II_EY_NBC%20Draft%-20TSA%20.pdf.

VIETNAM

2017 and 2018 data presented in this country profile are based on broodstock import data published online by Vietnam's Ministry of Agriculture and Rural Development (MARD). 2020 data are sourced from the Department of Animal Husbandry and Veterinary Medicine of Ninh Thuận Province.[1]

SUMMARY

Local production: 54,000-66,000
Imported: 162,000-198,000
Value $ million: 12-15

BROODSTOCK IMPORTS AMOUNT TO 166,000 IN 2018

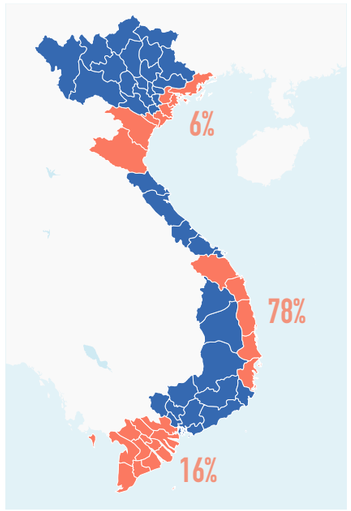
Vietnam's *L. vannamei* broodstock imports declined from 221,000 in 2017 to 166,000 in 2018. The decline of imports can be explained by an increase in domestic production of broodstock by Viet-Uc which in 2018 reportedly produced 60,000-65,000 broodstock. The total F1 specific pathogen free (SPF) *L. vannamei* broodstock market in 2018 amounted to 226,000-231,000 broodstock.

Official import data from MARD are not available for 2019. The assumption is that imports remained stable. Hawaii was the largest supplier, and supplied Vietnam with around 130,000 broodstock.[2] Other suppliers shipping from Thailand and Florida are believed to have continued to ship to Vietnam as well. As farmed shrimp production did not decline and domestic production of broodstock did not increase much, we assume that broodstock imports were likely at around the same level as in 2018.

SIS DOMINATES BROODSTOCK EXPORTS

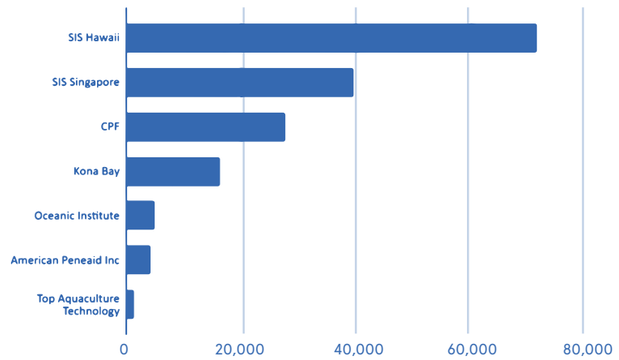
In 2018, with 111,000 broodstock, Shrimp Improvement Systems (SIS) was by far the largest supplier to Vietnam, shipping to more than 50 customers. CP Foods (CPF) was the second largest supplier and shipped 27,700 broodstock. Unlike SIS, CPF only supplied to its own hatcheries operated by CP Aquaculture Vietnam. Kona Bay Shrimp (Kona Bay) was the third and only other significant supplier of broodstock with 16,278 broodstock. Some of the smaller suppliers, together supplying 7% of imports, were American Penaeid Inc., Oceanic Institute and Top Aquaculture Technology. Although broodstock imports declined from 2017 to 2018, these market shares remained stable.

LOCATIONS OF BROODSTOCK IMPORTS 2018



Source: Ministry of Agriculture and Rural Development (MARD)

FIGURE 1: SPF *L. VANNAMEI* BROODSTOCK SUPPLIERS TO VIETNAM IN 2018 [3]



[1] Sub Department of Animal Husbandry Ninh Thuan Province.
See http://chicucctyninhthuan.gov.vn/Img/TOM%20BO%20ME/Danh_sach_Bo_Me080720.htm.
[2] J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1.
See https://issuu.com/aquafeed.com/docs/hfm_march_2020.
[3] Based on MARD data. See http://tongcucthuysan.gov.vn/.

2019 countrywide broodstock import data have not been published by MARD. However, data for the first half of 2020 from Ninh Thuận Province have been published by local authorities. Ninh Thuận was one of the major broodstock import hubs in 2018, accounting for 39% of total imports, and provides a good indication for new developments. In the first half of 2020, Ninh Thuận Province imported 32,000 SPF *L. vannamei* broodstock. SIS was the biggest supplier and supplied 45% of the total broodstock in the province (14,200). It supplied its broodstock primarily from Hawaii but a minor amount also came from Florida. Top Aquaculture Technology and CPF from Thailand came second and third, supplying respectively 6,100 and 5,400 broodstock.

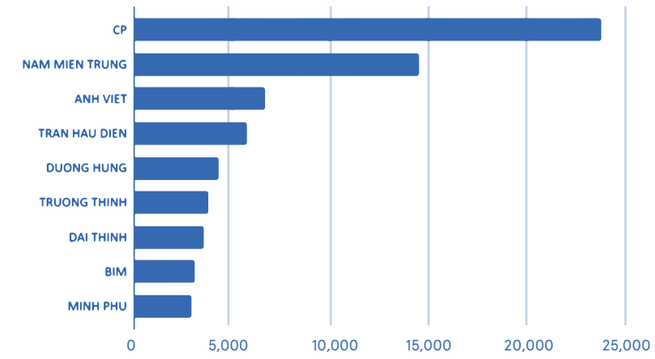
The Ninh Thuận imports reveal more. First, Benchmark Genetics USA supplied 4,300 broodstock, indicating that it is expanding its market in Vietnam now that its facility in Florida is up and running. Second, although Kona Bay only exported a minimal amount of broodstock (1,100), the company also supplied a significant amount of post-larvae (PL) to Minh Phu, Vietnam's largest vertically integrated shrimp producer. If Kona Bay exported PL already in 2018, its actual market share in Vietnam in 2018 may have been bigger than what we derived from the MARD data.

CP DOMINATES IMPORTS AND VIET-UC LOCAL PRODUCTION

Although around 550 hatcheries have been approved to produce *L. vannamei* PL from imported broodstock, only about 125 hatcheries belonging to 100 companies imported such broodstock in 2018.

Most of the broodstock in 2018 was imported by the South Central Coast of Vietnam in the provinces of Ninh Thuận (39%), Binh Thuận (35%), Bình Định (4%) and Phú Yên (2%), the main hatchery hub of the country. Smaller amounts were imported to the Mekong Delta in the provinces of Bạc Liêu (6%), Vũng Tàu (5%), Kiên Giang (3%), Bến Tre (1%) and Cà Mau (1%). Most nurseries and farmers are in fact located in the Mekong Delta and are supplied from the South Central Coast region.

FIGURE 2: SPF *L. VANNAMEI* BROODSTOCK IMPORTERS IN VIETNAM IN 2018 [4]



As can be observed from Figure 2, CP Vietnam Corporation is the largest importer and accounted for 15% of all imports in 2018. All of these supplies were destined for its own hatcheries in Vietnam, six of which were represented on the import list in 2018. Nam Mien Trung is the second largest importer, with a 9% market share. Contrary to Minh Phu, Nam Mien Trung supplied just one hatchery with its imports. The only other hatcheries that imported more than 5,000 broodstock were Anh Viet and Tran Hau Dien. Together, these four suppliers represented just over 30% of all broodstock imports in 2018. The remainder is widely spread over about 50 companies importing anywhere between 1,000 and 5,000 broodstock.

According to several news articles, in 2018 and 2019 Viet-Uc produced around 60,000-65,000 broodstock annually. In line with its share of the PL market, this would represent around 25% of Vietnam's total broodstock market. It is possible that the actual broodstock market is larger as for example Minh Phu does not only import broodstock also imported PL in 2020, which are most likely used to produce broodstock for its own hatcheries. Other companies such as BIM are also believed to be developing their own breeding programs.

TRENDS

- Vietnam's broodstock imports declined from 2017 to 2018 but are expected to have stabilized since then. Same as in other countries, demand in Vietnam for broodstock is also expected to continue to increase alongside the growth of farmed shrimp output.
- With its shrimp industry often in the forefront of innovation, local production capacity will likely increase as a result of the establishment of new local breeding programs and BMCs by local and international players and by government-supported research institutes.

[4] Based on MARD data. See http://tongcucthuysan.gov.vn/.

Advancing Biosecure Broodstock Nutrition

R. Chris Stock | Craig L. Browdy | Peter M. Van Wyk | Zeigler Bros., Inc.
www.zeiglerfeed.com

The shrimp broodstock industry is advancing quickly, bringing new potential for growth, disease resistance and other genetic improvements. Advances in our knowledge of the nutritional and physiological requirements of the maturation process have led to improvements in maturation feeding programs. Prepared diets designed specifically for the different physiological needs of each stage of broodstock development are now available. When accompanied with tailored feeding programs, producers can realize significant gains in the quality and consistency of nauplii while enhancing biosecurity.

Despite these advances, the industry remains heavily dependent on fresh and live feeds as mainstays of broodstock feeding programs. This dependence has cost the industry billions of dollars due to the well-documented role of these feeds in the transmission of diseases such as WSSV, AHPND, and EHP. Now more than ever, critical gaps in the nutrition and biosecurity of maturation programs must be prioritized, evolving broodstock feed programs to maximize the potential gains from genetic advancements. Achieving 100% replacement of fresh and live feeds requires a sustained industry effort, to ensure that broodstock programs everywhere can meet the growing demands for high quality nauplii.

Based on diligent research and over two and a half decades of experience producing shrimp broodstock diets, we draw on Zeigler's global expertise and its 85-year history of feed manufacturing to share perspectives on this subject.

Broodstock reared on advanced manufactured diets at Zeigler's Aquaculture Research Center (ZARC).

BROODSTOCK NUTRITION PROGRAMS

The physiological processes associated with maturation are complex and dynamic. The nutritional requirements of the shrimp change as the shrimp progresses through the maturation process. A well designed broodstock nutrition program ensures precise levels of nutrients and energy are delivered to the animals throughout the maturation process to consistently produce healthy, high quality nauplii. Customized broodstock diets should be introduced to animals from an early age to optimize the animal's potential and to put the producer in control. As the shrimp approach sexual maturity, a more nutrient dense diet should be phased in, enhancing gonadal development and conditioning. As the shrimp enter active reproduction, special maturation diets must be fed to support repetitive spawning of healthy eggs and sperm.

Properly formulated diets and good feeding protocols ensure that animals have a consistent delivery of critical nutrients such as phospholipids, HUFAs, carotenoids, amino acids and vitamins at the required levels for their developmental stage. Advanced broodstock diets contain additives to assure robust immune balance and gut health. Manufactured diets offer the safest and most reliable option for delivery of the proper balance of nutrients and health additives.

Live locally caught polychaetes are a significant biosecurity risk for pathogens.

Photo: Jennifer Doherty

Attractability and palatability of manufactured diets are critical to ensuring adequate nutrient uptake.

LIVE AND FRESH FEEDS

A wide variety of fresh and live feed are commonly used in maturation feeding programs, including squid, polychaetes, mussels, oysters, clams, Artemia biomass and krill. The nutritional profile and overall quality of live and fresh feeds varies based on the sourcing location, seasonality, and changes in environmental conditions. Moreover, nearly every hatchery uses different combinations and percentages of fresh and live feeds, resulting in wide nutritional variations between hatcheries.

In Asia, live polychaetes are widely used because they support very high nauplii production levels. This reliance on wild-harvested live polychaetes for enhancing fecundity is a major contributor to introduction and spread of diseases such as WSSV, AHPND, and EHP. Although freezing the worms can reduce infectivity of some pathogens, nauplii productivity suffers and many producers are unwilling to sacrifice higher nauplii production for the sake of improved biosecurity.

Farm-raised frozen polychaetes are a biosecure alternative to live polychaetes. Likewise, frozen squid sourced from areas geographically isolated from shrimp production regions also reduce the risk of introduction of pathogens into the hatchery. However, frozen fresh feeds consist of 80-90% water, so air freight adds a significant investment per unit of dry weight nutrition.

Inventory management of fresh and live feeds present their own challenges. High quality frozen fresh feeds are typically imported using a cold storage chain adding costs and risk to maintain shelf life. Alternatively, manufactured diets offer a longer shelf life, easing inventory management and ensuring greater consistency for the maturation program.

BIOSECURITY

To minimize the risk of introducing disease from wild and farm reared spawners, the use of specific pathogen free (SPF) broodstock is rapidly becoming the industry standard. Governments also strictly regulate the import process. This comes at a significant cost to producers. Ironically, once reaching the hatchery, the disease-free status that managers paid so much to obtain is frequently compromised by the feeding of fresh and live feeds to maximize nauplii production. While this may increase short term profits for the hatchery owner, the economic losses to farm operators and to the industry totals billions of dollars every year.

A NECESSARY TRANSITION

The arguments to increase the use of manufactured diets are overwhelming but resistance to change is significant. As Albert Tacon, a recognized leader in the subject of aquaculture nutrition has stated, *"In view of the potential disease risks from the use of pathogen-contaminated, live and fresh natural feed items, it would be prudent for the shrimp industry to sacrifice lower hatchery performance and contamination of their valuable specific pathogen-free broodstock by moving over completely to the use of commercially manufactured biosecure larval and maturation feeds." Journal of the World Aquaculture Society Volume 48: 381-392*

A well-designed maturation feeding program utilizes biosecure feeds in quantities adjusted for broodstock consumption levels. To be effective, prepared feeds must be consumed in quantities necessary to provide the desired nutritional impact. Because different feeds vary with respect to moisture content and available nutrients are largely associated with the dry matter, feed rates should be based on the percentage of dry matter in the feeds. Complete replacement of all fresh and frozen feeds other than squid has been successfully achieved using high quality formulated feeds fed to replace fresh feeds on an equivalent dry weight basis.

When manufactured diets are introduced, a highly conservative approach can impair progress. Traditionally, manufactured diets are fed at 1 to 1.5 percent of tank biomass. However, feeding of high-quality manufactured maturation diets at such low levels mutes their nutritional impact. For best results, an attractive advanced diet should be fed at >2.5% dry weight to tank biomass. The manufactured feed should be greater than 50% of the total dry weight fed. Utilization of older animals that have been habituated to fresh feeds for testing new diets can also be problematic. Younger animals conditioned on prepared feeds from stocking provide the best results.

In summary, technologies for prepared maturation diets are improving. Better ingredients optimized nutritional composition, improved attractability, effective additives and innovative manufacturing technologies are contributing synergistically to improving performance. When properly incorporated in a complete maturation program these feeds provide a basis for reducing use of live and fresh feeds, enabling more biosecure and robust nauplii production.

ZEIGLER'S COMPLETE MATURATION PROGRAM

Zeigler's unique Broodstock 1-2-3 Maturation Program encompasses a range of diets specially adapted for every phase of a broodstock program.

Once animals have been isolated for future breeding, conditioning can begin to prepare for the best long-term results. A tailored feed like Zeigler's Shrimp Broodstock diet can be introduced to animals as small as 7g and is suitable for use in open systems.

Once animals begin the physiologically demanding phase of gonadal development the need for more nutrient dense diets becomes more acute. Zeigler's Shrimp Maturation Conditioning Diet is optimized with micronutrients to optimize gonad reserves, accelerate mating rates and increase spawn sizes. This diet is specially designed for use tank-based systems.

Upon reaching the active spawning phase, consistently supplying optimized nutrition reaches new levels of importance as metabolic demands on broodstock peak. Zeigler offers two unique diets for this stage, EZ Mate and Redi-Mate, which both contain extremely high levels of carotenoids and vitamins to promote and sustain good spawning rates and increase the number and quality of nauplii per spawn. Both diets have been carefully developed to maximize attractability and ensure uptake of vital nutrition to sustain optimized production.

EZ Mate is a highly adaptable powdered diet which is made into a dough by the customer. This allows customization of the feed by adding other ingredients and shaping the diet into a preferred format. Redi-Mate, Zeigler's newest broodstock diet, encompasses the latest nutritional science and manufacturing technologies resulting in a highly attractive, semi-moist pellet, which is ready to feed.

Photo: Global Gen

Global Gen’s facility on Lombok

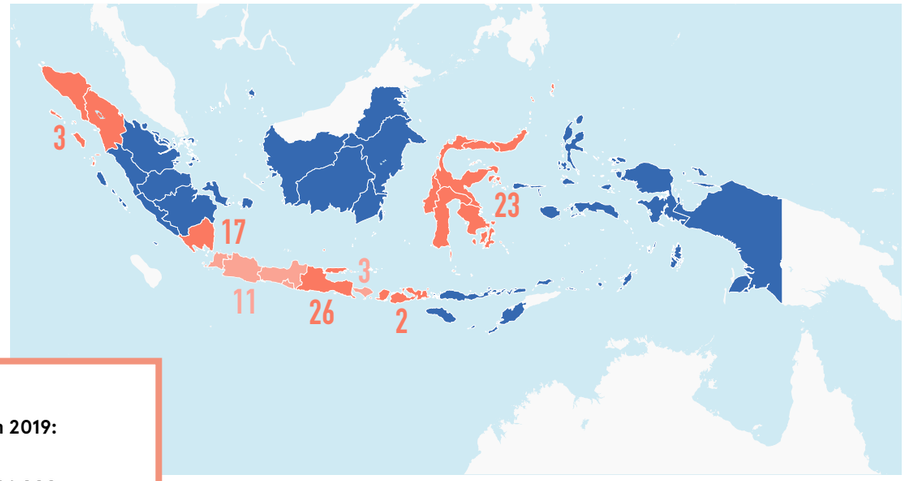
INDONESIA

All the data presented in this country profile on Indonesia's broodstock sector are based on international trade data obtained from Indonesia's statistics bureau (the BPS), international trade data from ITC Trademap, and data obtained through interviews with local industry stakeholders.

SUMMARY

Local production in 2019:
84,000-102,000
Imported: 77,000-94,000
Value $ million: 9-11

LOCATION OF GOVERNMENT APPROVED *L. VANNAMEI* HATCHERIES IN 2020

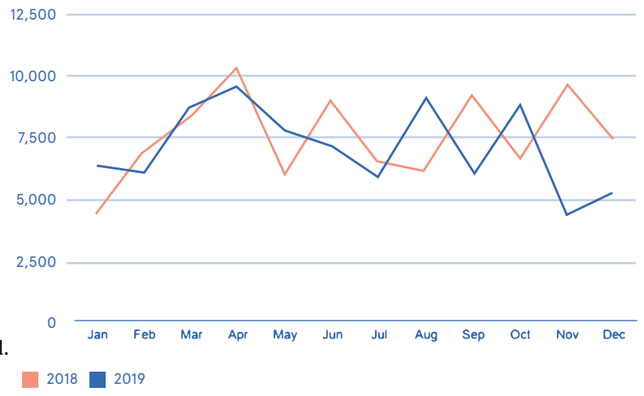


Source: Ministry of Marine Affairs and Fisheries

IMPORTS IN 2019 ACCOUNTED FOR AROUND 85,000 BROODSTOCK

Indonesia's broodstock imports slightly declined from 100,000 in 2016 to 94,000 in 2017, to 91,000 in 2018 and 85,000 in 2019.[1] In 2018 and 2019, imports increased from January to April. Farmers tend to stock their first crop early in the year to harvest before the start of Ramadan. After Ramadan and towards the end of the year, farmers generally stock for another two crops. The drop in imports at the end of 2019, however, suggests that fewer farmers went for a third crop (see Figure 1).

FIGURE 1: ESTIMATED F1 *L. VANNAMEI*[2] BROODSTOCK IMPORTS IN INDONESIA IN 2018 AND 2019[3]



As Indonesia has banned broodstock imports from Thailand, it imports most of its broodstock from the US. The number of broodstock supplied to Indonesia from Hawaii declined by nearly half in the period from 2015 to 2019: from just below 100,000 in 2015 to around 51,000 in 2019.[4] The total supplies from the US were still around 85,000 broodstock as Florida substituted part of the supplies.

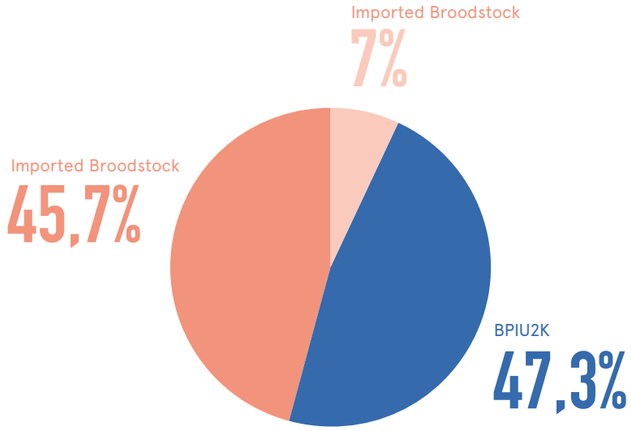
[1] Broodstock import numbers are calculated by dividing the total value of broodstock imports in dollars by $55, which we consider here to be the average price per animal.
[2] All references are to SPF broodstock, unless specified otherwise.
[3] Source: ITC Trademap. See https://www.trademap.org/.
[4] J. Wyban, *SPF Shrimp Technology: Past, Present & Future* (2020), Hatchery Feed & Management, Vol. 8, Issue 1. See https://issuu.com/aquafeed.com/docs/hfm_march_2020.

Kona Bay Shrimp (Kona Bay) and Shrimp Improvement Systems (SIS) are the biggest suppliers to the Indonesian market. Kona Bay, the largest supplier of the two, sells on the open market and has many customers throughout the country. SIS has an exclusive partnership with CP Prima, Indonesia's largest vertically integrated shrimp company. As such, its exports fluctuate with CP Prima's market share on the post-larvae (PL) market. SyAqua, shipping from Florida, also expanded its market in Indonesia (between 2017 and 2019) but is still a small player compared to Kona Bay and SIS.

DOMESTIC PRODUCTION OF F1 *L. VANNAMEI* BROODSTOCK ACCOUNTED FOR 100,000-110,000

Figure 2 provides an estimate of the total F1 *L. vannamei* broodstock market in Indonesia. BPIU2K and Global Gen account for the largest market share in terms of production.

FIGURE 2: ESTIMATION OF DIVISION OF IMPORTED AND LOCALLY PRODUCED *L. VANNAMEI* BROODSTOCK IN 2019[5]



The Ministry of Marine Affairs and Fisheries started its current *L. vannamei* breeding program some five years ago. The program is managed by BPIU2K (the Karangasem-Bali Superior Shrimp Broodstock Production Center). Although documentation of the breeding program states that it is based on four genetic sources,[6] it is not entirely clear which founder broodstock (F0) were used for the program. At least part of the founder broodstock originated from Kona Bay.[7] The program has developed two lines: one focusing on growth and another on disease tolerance.

BPIU2K started supplying *L. vannamei* PL and broodstock to the Indonesian market from 2017 onwards. Production increased from 16 million PL and 65,000 broodstock in 2017 to more than 51 million PL and 86,700 broodstock in 2018. Although the numbers for 2019 have not been published yet, the strategic plan for 2019 includes a broodstock production target of 88,000, a bit over the target for 2018, which BPIU2K also accomplished. BPIU2K's broodstock is locally known as *Vannamei Nusantara*. BPIU2K sells to small hatcheries and farmers through government-funded support programs but is also active on the open market.

Global Gen is Indonesia's only privately owned domestic producer of F1 *L. vannamei* broodstock. The company operates its breeding program from Lombok and used to produce around 25,000 broodstock annually. It supplies broodstock domestically and to several markets in Asia. The earthquake in August 2018 thwarted Global Gen Indonesia's (Global Gen) broodstock production and the company needed the first half of 2019 to recover. As a result, in 2019, Global Gen produced only around 13,000 broodstock, sold almost entirely on the domestic market.

When we assume that BPIU2K met its 2019 production target, then, jointly with Global Gen, domestic production of Indonesia in 2019 accounted for 100,000 broodstock. Indonesia's total market for F1 *L. vannamei* broodstock in 2019 thus amounted to 186,000 broodstock (see Figure 2).[8]

FEW PLAYERS DOMINATE THE PL MARKET

According to the website of the Ministry of Marine Affairs and Fisheries (locally known as KKP), Indonesia currently has 86 government-accredited *L. vannamei* hatcheries belonging to at least 70 companies. As Indonesia does not publish detailed broodstock import data, exact market shares are unknown.

[5] Source: BPIU2K 2019 Annual Report, BPS Indonesia 2019 and *Shrimp Insights* 2020 market study.
[6] BPIU2K's 2017 and 2018 Annual Reports.
[7] See https://money.kompas.com/read/2017/06/08/152758026/kkp.dorong.broodstock.center.perbaiki.kualitas.udang.vaname.
[8] One industry source argues that actual domestic broodstock production may have been slightly below 100,000 as the import number of 85,000 has been confirmed by local industry representatives, based on a calculation of 2019's PL market, the total broodstock market would be somewhere in the range of 150,000 to 180,000. Hence, at most local production would be 95,000.

There are only two companies with a countrywide presence in the hatchery sector. CP Prima, the largest, operates nine shrimp hatcheries across the country. According to a report of the Bolton Consultancy Group in 2019, CP Prima has a share of 50% of Indonesia's PL market. The actual share might be smaller due to a change in the company's business model in 2019. This resulted in the company abandoning most of its contract farming arrangements under which contracted farmers were obliged to use CP Prima's PL. As a result, some local industry sources say that CP Prima's PL sales may have declined to a market share of 35% in 2019. If CP Prima accounted for a similar share of broodstock imports, these would have been around 30,000-40,000. CP Prima has an exclusive partnership with SIS and all its broodstock are sourced from SIS.

Suri Tani Pemuka (STP), a subsidiary of agri-food company Japfa, also has a countrywide presence. STP operates six hatcheries, feed mills and is involved in shrimp processing.

Both CP Prima and STP are vertically integrated companies and thus have the advantage of being able to offer farmers all required inputs. Most other hatchery operators have only one or two hatcheries and sell mainly locally or depend on long-distance air and road transport to reach customers further away. Some of these local players have major market shares with farmers in their surroundings.

TRENDS

- Shrimp production in Indonesia is surging. It is the government's ambition to increase production by 250% over the next three years. While this aim might be overly ambitious, an increase of farmed shrimp output by only 50% would already mean an additional demand for approximately 100,000 broodstock.
- Local production capacity of F1 *L. vannamei* broodstock is around 160,000. In 2019, 100,000 broodstock were actually produced by BPIU2K and Global Gen. With a spare capacity of 60,000 broodstock and a minimal additional projected demand of 100,000 broodstock, demand for imported broodstock is expected to increase by at least 40,000 in the next three years.
- Whether increased demand will actually result in more imported broodstock depends on new investments. If the Indonesian government, the private sector or international broodstock suppliers invest in local production capacity, actual broodstock imports may decline. Further, potential growth of local F2 broodstock production may negatively impact broodstock imports.

PHILIPPINES

The data presented in the Philippines country profile is based on detailed broodstock import data published on a continuous basis by the Bureau of Fisheries and Aquatic Resources (BFAR).[1]

SUMMARY

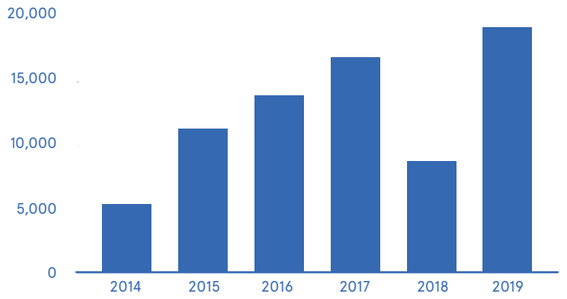
Imported: 19,000

Value $ million: 1

IMPORTS IN 2019 ACCOUNTED FOR ALMOST 20,000 ANIMALS

The Philippines is a small player compared to other shrimp producers in Asia, but *L. vannamei* production has been increasing steadily over the past couple of years and reached 60,000 MT in 2019. Broodstock imports increased from just 5,000 in 2014 to almost 20,000 in 2019. The drop in imports in 2018 as shown in Figure 1 was due several cyclones that caused severe flooding and hampered shrimp production in that year. In 2019, the positive trend continued.

FIGURE 1: *L. VANNAMEI* BROODSTOCK IMPORT TREND FROM 2014-2019[2]



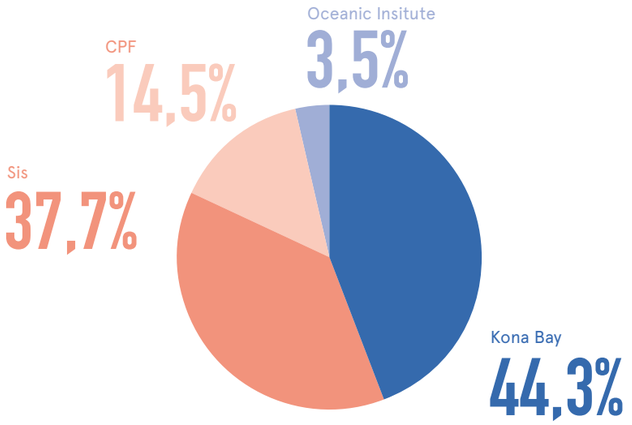
KONA BAY AND SIS: THE LARGEST SUPPLIERS OF BROODSTOCK IN 2019

In 2019, Kona Bay Shrimp exported just over 8,000 broodstock to the Philippines, and Shrimp Improvement Systems exported just under 8,000. CP Foods Thailand only gained market access recently but is likely to increase its supplies. The Oceanic Institute was the only other broodstock supplier to the Philippines in 2019.

FOURTEEN COMPANIES IMPORTED *L. VANNAMEI* BROODSTOCK

The BFAR regulates the imports of broodstock and accredits hatcheries and farms to produce *L. vannamei* shrimp. In 2020, 40 hatcheries have been permitted to import broodstock and 200 farms can grow *L. vannamei*.

FIGURE 2: ESTIMATION OF DIVISION OF IMPORTED AND LOCALLY PRODUCED *L. VANNAMEI* BROODSTOCK IN 2019[3]



Fourteen of the registered hatcheries actually imported broodstock in 2019. The top 5 importers were CPF Philippines Cooperation (CPF Philippines), Aquatic Ranch Development, Feedmix Specialist (Fisher Farms), Dobe International Export, and the Oversea Feeds Corporation. Together they represent 76% of total imports (see Figure 2). CPF Philippines, Feedmix Specialist and the Oversea Feeds Corporation are all fully integrated shrimp producers.

TRENDS

- *L. vannamei* farming is expanding in the Philippines, and alongside production, the demand for broodstock is also expected to grow over the next couple of years. With an average annual growth rate of 60% per year between 2014-2019, this is a good outlook for future demand.

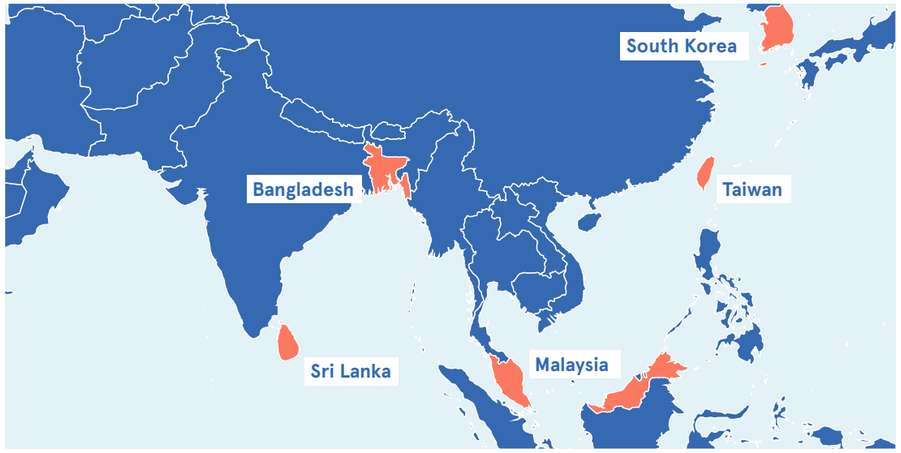
[1] BFAR online portal with broodstock import data and lists of registered farms for import, and production of specific pathogen free *L. vannamei*: http://bfar.da.gov.ph/BFAR_AQUACULTURE?id=16.

[2] Source: BFAR. See https://www.bfar.da.gov.ph/services?id=773#post.

[3] Idem.

OTHER ASIAN MARKETS

Although less important than the big Asian markets like China, India, Indonesia and Vietnam, Asia also has some small *L. vannamei* producers that import broodstock. The smaller importers are South Korea, Taiwan, Malaysia, Sri Lanka and Bangladesh.



SOUTH KOREA

While South Korea is not a country often associated with shrimp production, it actually has a vibrant indoor and outdoor shrimp farming sector with at least 50 to 100 farms that grow *L. vannamei* for the live shrimp market in the country. Although exact numbers are not available, South Korea imports somewhere between 10,000 and 15,000 broodstock annually.

TAIWAN

Taiwan (Chinese Taipei) was one of the first importers of specific pathogen free (SPF) *L. vannamei* broodstock in Asia. Although Taiwan's shrimp production has declined since then, it still has a vibrant shrimp farming sector. In 2019, Taiwan imported around 7,000 to 8,000 broodstock from the US, Singapore and Thailand.

MALAYSIA

Malaysian imports of *L. vannamei* broodstock reported by the Malaysian Department of Fisheries declined from almost 10,000 in 2016 to just below 5,000 in 2018. Although 2019 import figures have not yet been reported, looking at approved import capacity – which increased from 2018 to 2019 – it is likely that 2019 imports will be closer to 2018 numbers. There are eight companies approved to import *L. vannamei* broodstock: Asia Aquaculture (subsidiary of CP Foods (CPF)), KS Pekan Hatchery and Kembang Subur account for almost 80% of approved capacity. Besides CPF, SyAqua is a major supplier to the Malaysian market. Kona Bay Shrimp operates its own NBC and BMC in Malaysia but its production capacity and actual production are unknown.

SRI LANKA

Sri Lanka only started to introduce *L. vannamei* commercially in 2018. The country aims to increase *L. vannamei* production to around 60,000 MT over the next couple of years. Currently, only CP Foods Thailand and Kona Bay Shrimp are approved to supply to Sri Lanka. Only CPF's subsidiary Lotus Aquaculture and Taprobone Seafood Group are approved for imports of SPF broodstock.

BANGLADESH

Bangladesh only started trials with *L. vannamei* production in 2019. If the government eventually permits the introduction of *L. vannamei*, Bangladesh's semi-intensive farmers are expected to switch to *L. vannamei* and other companies may decide to venture into *L. vannamei* farming as well, creating a new market for SPF *L. vannamei* broodstock.

LATIN AMERICA

Most producers in Latin America do not develop or use specific pathogen free (SPF) *L. vannamei genetics*. Shrimp farming in Latin America occurs mainly in extensive farms in which pathogens are widely present. SPF animals are believed to perform less well than all pathogens exposed post-larvae (PL) and therefore SPF suppliers have not managed to develop a stignificant market in the region. However, some countries deserve some attention.

MEXICO

Blue Genetics, the only SPF *L. vannamei* broodstock producer in Latin America, operates from Mexico. All broodstock and PL exports from Mexico are accounted for by Blue Genetics. The value of exports from Mexico rapidly increased from $769,000 in 2016 to $2.8m in 2018. Mexico's main export markets in 2018 were India (71%) and Thailand (11%). Other markets were China, the US and Vietnam. 2019 data have not been released yet. Blue Genetics has partners in India and Thailand with whom it operates local broodstock multiplication centers.

Blue Genetics also supplies to Mexico's domestic market. Farmers in Mexico operate relatively intensive production systems with stocking densities comparable to those in, for example, India. Other broodstock suppliers, such as Sea Products Development, also ship minor volumes of broodstock and PL to Mexico.

CENTRAL AMERICA

Most shrimp farmers in Central America operate extensive production systems to farm their shrimp. However, especially in Guatemala, farmers use more intensive methods of farming. The main vertically integrated shrimp producer of the country, Acuamaya, is responsible for about 90% of domestic PL supply. Although Acuamaya previously imported some SPF broodstock, the company nowadays operates its own breeding program.

Other Central American countries are in a similar situation, for instance Nicaragua and Honduras, where large companies like Seajoy (Cooke Aquaculture), Farallon and Pescanova operate breeding programs with which they supply most of the farms in their vicinities. In Central America's relatively small markets, there is not much space for other players.

BRAZIL

Brazil's shrimp farmers also operate more intensive production systems with stocking densities comparable to those in Asia. Some farmers, such as the company Camanor in which CP Foods has bought a stake, even invest in super-intensive production systems where SPF *L. vannamei* broodstock with fast growth rates have considerable added value. The Brazilian shrimp industry is currently lobbying with the government to permit imports of SPF broodstock from selected suppliers.[1] If the government approves this request, Brazil could become a major new market for SPF broodstock suppliers.

[1] See https://www.undercurrentnews.com/2018/07/30/ecuador-exec-silence-on-thai-plan-shows-brazil-shrimp-lobbys-contradictory-stance/.

SPF P. Monodon broodstock suppliers

While *L. vannamei* has conquered the shrimp industry and is produced the most, some countries still produce significant amounts of *P. monodon*. This species is cherished for its premium features, but is more difficult to cultivate. It grows into larger sizes, has a darker colour, a stronger taste and a firmer texture. You could argue that it is a more sustainable choice as it is mostly cultivated in extensive production systems, stocked with only 1-5 post-larvae (PL)/m2. In a way, you could view extensively cultivated *P. monodon* as the free-range chicken among shrimp.

Cà Mau in the Mekong Delta in Vietnam is the largest extensive producer of *P. monodon*. But production of this shrimp in e.g. South West Bangladesh, North East India, East Kalimantan in Indonesia, and Rakhine in Myanmar should not be overlooked. Unfortunately, many *P. monodon* hatcheries providing PL to farmers do not use domesticated broodstock but broodstock from the wild. With wild shrimp stocks under pressure, this undermines the sustainability argument of extensively reared *P. monodon*.

While generally the production of specific pathogen free (SPF) *P. monodon* broodstock is regarded to be more challenging than that of SPF *L. vannamei* broodstock, the number of companies offering SPF *P. monodon* broodstock is on the rise. We list the main suppliers here.

MOANA TECHNOLOGIES

Moana Technologies is the world's largest supplier of SPF *P. monodon* genetics. The company operates with a nucleus breeding center (NBC) from Hawaii. Moana Technologies developed its breeding program with wild broodstock from Asia and Africa and currently manages more than 150 families in its NBC in Hawaii. From Hawaii, the company supplies broodstock and PL to for instance Indonesia, Bangladesh and the Philippines. Since 2008, Moana has operated a breeding multiplication center (BMC) in Vietnam where it has the capacity to produce 60,000 broodstock annually. Allegedly, Moana plans to also establish BMCs in India and other Asian countries.

CPF

Thailand-based CP Foods (CPF) has also developed a breeding program for SPF *P. monodon*, which the company had initiated more than 10 years ago. In a presentation at WAS 2018, Robins McIntosh showed that CPF's broodstock has made much progress in terms of disease tolerance, growth and uniformity. CPF produces mainly for its own hatchery operations in Asia and is not selling its broodstock on the open market. Its own hatcheries are able to offer SPF *P. monodon* PL to farmers across Asia. In 2019, CPF is believed to have produced around 15,000 *P. monodon* broodstock, which might increase to about 30,000 in 2020.

UNIMA

Unima is one of the largest, if not the largest, producer of *P. monodon* in Madagascar. Its NBC and hatchery operate under the name Aquaculture de la Mahajamba (Aqualma). The company's breeding program was started in 2000 and, ever since 2003, has supplied 100% of the demand of its own farming operations. As an SPF certified breeding program, the company also targets exports and, since March 2019, is one of two approved suppliers of SPF *P. monodon* broodstock to India. It is rumoured that Unima is planning to open a hatchery or BMC in India.

KONA BAY

The *P. monodon* genetics line of Kona Bay Shrimp (Kona Bay) was developed between 2007 and 2015 in collaboration with the Department of Fisheries in Brunei. The broodstock were transported to its facilities in Hawaii, where the United States Department of Agriculture listed Kona Bay's *P. monodon* genetics line as SPF certified. It is expected that, later this year, the company's *P. monodon* broodstock will be released for commercial sales.

VIET-UC

Besides *L. vannamei*, Viet-Uc has also started its own breeding program for *P. monodon*. The breeding program is still in its infancy, though, and it might take another couple of years before its *P. monodon* broodstock is ready for commercial use.

Annex 1

Estimation of F1 SPF L. vannamei *broodstock market sizes in 2019*

	Imported			Locally produced			Total market		
	Absolute estimate	Minimum	Maximum	Absolute estimate	Minimum	Maximum	Absolute estimate	Minimum	Maximum
CHINA	596,000	536,400	655,600	59,600	53,640	65,560	655,600	590,040	721,160
INDIA	233,425	233,425	233,425	36,000	32,400	39,600	269,425	265,825	273,025
VIETNAM	180,000	162,000	198,000	60,000	54,000	66,000	240,000	216,000	264,000
INDONESIA	85,000	76,500	93,500	93,000	83,700	102,300	178,000	160,200	195,800
THAILAND	20,600	18,540	22,660	72,400	65,160	79,640	93,000	83,700	102,300
MALAYSIA	15,000	13,500	16,500	0	0	0	15,000	13,500	16,500
PHILIPPINES	19,297	19,297	19,297	0	0	0	19,297	19,297	19,297
OTHER	35,000	31,500	38,500	35,000	31,500	38,500	70,000	63,000	77,000
TOTAL	**1,184,322**	**1,091,162**	**1,277,482**	**356,000**	**323,000**	**387,000**	**1,540,322**	**1,414,162**	**1,664,482**

Annex 2

Calculation of estimation of number of SPF L. vannamei *broodstock from Florida and Texas, and Thailand in 2019*

	Florida and Texas		Thailand	
	Minimum	Maximum	Minimum	Maximum
SIS	67,500	110,000		
CP			100,000	100,000
SYAQUA	26,000	90,000	26,000	90,000
API	288,000	320,000		
TOP AQUACULTURE			105,000	130,000
PRIMO	50,000	60,000		
SPD	10,000	15,000		
BENCHMARK	5,000	7,000		
TOTAL	**446,500**	**602,000**	**231,000**	**320,000**

Annex 3

Estimation of market size of the main SPF L. vannamei *broodstock suppliers in 2019*

	Estimated volume 2019[1]									Estimated range	
	China	India	Indonesia	Vietnam	Thailand	Malaysia	Philippines	Other	Total calculated estimate	Minimum # brood-stock (-10%)	Maximum # brood-stock (+10%)
AMERICAN PENEAID INC.	280,120	8,300		7,200					295,620	266,058	325,182
SHRIMP IMPROVEMENT SYSTEMS	5,960	99,786	27,440	117,600	8,370	450	7,333	7,700	274,639	247,175	302,103
KONA BAY SHRIMP	5,960	100,029	50,960	14,400	6,510	450	8,491	11,900	198,700	178,830	218,570
CHAROEN POKPHAND FOODS	47,680			33,600	55,800	7,500	2,895	8,400	155,875	140,287	171,462
SYAQUA	89,400		6,860		6,510	6,600		7,000	116,370	104,733	128,007
TOP AQUACULTURE TECHNOLOGY	95,360			2,400					97,760	87,984	107,536
VIET-UC				60,000					60,000	54,000	66,000
PRIMO BROODSTOCK	47,680								47,680	42,912	52,448
BLUE GENETICS		39,200			7,500				46,700	42,030	51,370
SEA PRODUCTS DEVELOPMENT	5,960	8,200							14,160	12,744	15,576
GLOBAL GEN INDONESIA (PT BIBIT UNGGUL)			13,000						13,000	11,700	14,300
MOLOKAI BROODSTOCK COMPANY	4,026			5,960					9,986	8,988	10,985
OCEANIC INSTITUTE				4,800			579		5,379	4,841	5,917
NAB					*Not yet started in 2019*						
BENCHMARK					*Not yet started in 2019*						

[1] The numbers here are derived from the sources as mentioned on p. 31-32.

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