The exciting future
of aquaculture

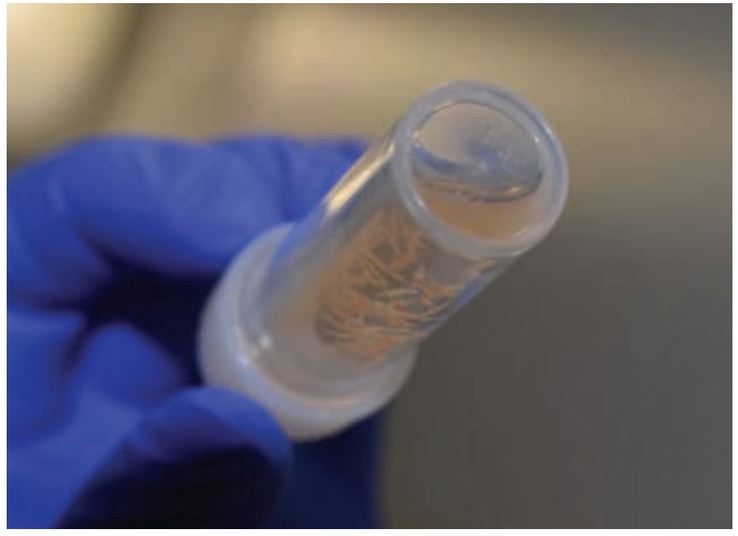
Predicting the future is typically laden with risk. There are however a few safe bets. Perhaps the safest prediction is that the output of high quality protein from the global aquaculture industry will continue to increase over the next several decades. There are few who would argue that the production of high-quality proteins and fats from farmed aquatic animals is not essential for humanity to feed itself as our population swells to the 9 to 10 billion level over the next three decades. The actual numbers are not important; the increase in demand for reasonably priced high quality seafood will continue to increase one way or another.

*By: Ph.D Stephen G. Newman**

The challenge lies in figuring out how do we get there from here? Last year, prior to Covid-19 (C19), many sectors were enjoying unprecedented market growth. In a few short months, this has changed. C19 is wreaking havoc on all levels of food production. The impact is variable with some elements of global aquaculture yet to feel the full impact of this raging pandemic.

The market is in a highly volatile state. Demand is off and producing countries are dealing with the fallout of widespread C19. For the immediate future we can expect more of the same. How long it will take for humanity to return to pre-Covid rates of consumption of seafood is anybody's guess. Local consumption of lower cost species will continue but the large import markets have been disrupted. It is not unreasonable, given the path we are on, that the total output of the international shrimp farming community will drop by a third. Likely farmed salmon, a high value fish, will also see something similar. This quite sudden and dramatic impact will bankrupt vulnerable farmers and suppliers. There will be many who are affected to some degree but not enough to drive them out of business. Some will actually come out stronger. Consolidation in some sectors will likely occur as those companies who have large cash reserves will guy on an acquisition spree.

Even after an effective and long-lasting vaccine is available it will take some time until enough people have been immunized before the world could return to "normality". There should be a gradual return to some



Photograph: Genics Pty Ltd.

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semblance of normality as the disease comes under control. This will take at least 24 months from early 2020 conservatively before we can even begin. The vaccine has to be developed, found to be safe and effective with minimal side effects.

As C19 continues to rage, we can expect to see the growth rate of all global aquaculture to be reduced significantly. We should expect to see a few years with very low to negative growth rates. Service sectors everywhere are heavily impacted. As long as restrictions are in place that limit seating in restaurants and the fear of contracting C19 persists there is little hope of this sector recovering any time soon. However, it will recover; hopefully not with changes that impact everything post C19.

It is possible that this may actually drive an increase in efficiency. The vast majority of shrimp and fish farming globally is not science based. It differs little from how it might have been done a hundred years ago. This will not change quickly. Those producing countries reliant on the US dollars, European euros, Chinese Yuan and Japanese yen have an incentive to push the rate of change.

I envision a future where science based aquaculture dominates. What does this mean? Much greater control will be exerted over all aspects of the process. The goal will be to become truly sustainable, reduce the overall costs of production, and optimize the production of a given species. As I see it this will require:

1. The consistent implementation of the levels of biosecurity required to ensure that all below is achieved in a sustainable manner.
2. Genetic improvement to ensure faster growth and increased tolerance to stress in general and to specific pathogens.
3. Development of truly SPF stocks using the methods established for use in terrestrial agriculture.
4. Move towards indoor highly controlled systems using RAS and biofloc or a combination.
5. Reduce environmental impacts while improving productivity.

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Improving biosecurity

Without this there can be no real sustainability. Sustainability will require a dramatic shift in how farmers and regulators think. The single greatest issue today is the failure to break the cycle of pathogens entering the production system via broodstock. The terms SPF, SPR, SPT have clear cut definitions that have been largely ignored heretofore. More often than not, they are used in marketing and puffery. All too often farmers accept what they are being told at face value and regulators do not seem to grasp what is needed to truly achieve these things. Repeatedly we see new diseases being introduced and spread and even many existing pathogens that could have been eliminated being passed on endlessly in what has become an all too vicious cycle.

The technology and the tools exist today to ensure that this cycle is broken. No one will use wild broodstock. One cannot screen for pathogens that we do not know exist. Animals will not be allowed to be called SPF unless they are from facilities that have followed the established requirements, with some modifications, to accommodate the high levels of fecundity that shrimp and many fish species have. Every individual broodstock will be screened for all known pathogens. The technology for doing this cost effectively exists today (Genics Pty Ltd.). Broodstock will be produced in these highly bio secure facilities with each country having their own centers. These animals will be clean and free of all known pathogens and held in a manner that ensures that they cannot be exposed to new pathogens.

Genetic improvement

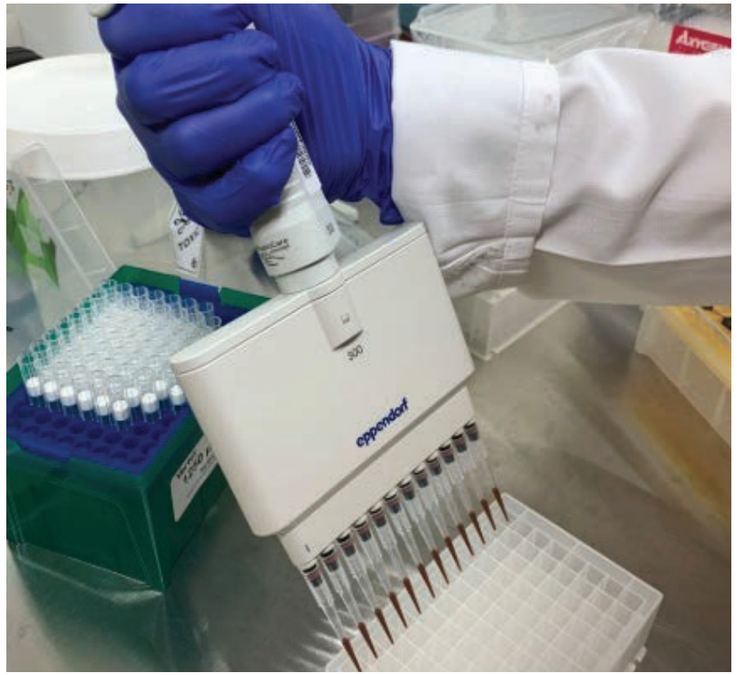
The overall goal of sustainability encompasses market considerations as well. After all if the costs of production are too high and continue to be volatile, this affects the farm gate price and in turns the price to consumers. The higher the price, the smaller the potential market. There are several approaches that can be used to reduce the overall cost of production.

Genetic modification will be an essential element of this. There are two generalized approaches. One is (natural) selection. This entails selecting those animals based on phenotype that express the genes that they need in order to grow faster, larger, be disease resistant or pathogen tolerant, etc. This approach is the method of choice among man of those companies that have dedicated themselves to selling genetically improved broodstock. In the case of farmed shrimp, this approach has already resulted in significant advances. Using conventional selection techniques the white shrimp, *P. vannamei*, has been successfully domesticated. A large multinational (Charoen Pokphand Foods Ltd. public company Thailand) has devoted considerable resources to this and they produced lines of shrimp that will pave the way for a sustainable future.

They have families that, under the right conditions, will grow more than

a gram per day, that are tolerant and/or resistant to some of the common pathogens affecting farmed shrimp and that do not sexually differentiate or do so much later than the wild type they started from. These shrimp grow well at very high densities and with proper management have very low feed conversion ratios and high survivals. This widespread use of these lines can change the entire face of the global shrimp industry. By being able to produce 4 to 5 cycles a year of shrimp at high densities from truly SPF broodstock with FCRs a bit over 1 and high survivals, the costs of production can be dramatically dropped. Wide spread adoption is however not guaranteed at this time. There are a few reasons for this although one of them has no business even being considered. Several major shrimp producing countries are ensuring that their industries will continue to be pseudoscience based by failing to understand what a truly SPF animal actually is and what is production entails.

The second approach is genetic manipulation by adding genes, altering gene function by impacting local gene expression, etc. It is unfortunate that those NGOs who fear the use of genetically modified organisms (GMOs) are able to exert the influence that they have on the market place. Fear mongering ensures the perpetuation of pseudoscience as well. Economically desired traits are generated via a number of methods to give the desired outcome. There are very few examples of GMO fish and the one company, Aquabounty, that has been at this the longest, is still facing regulatory hurdles and market based biases. There is no evidence that the additions that they have made, which result in salmonid smolts growing much quicker, reducing the costs of production, are in anyway even remotely harmful.



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Other companies are looking at similar things and with the advent of CRISPR technology it is possible to fine tune the process to the extent where single mutations can be generated that have a positive impact on the value of the crop, with no traces that this is in fact is what occurred. The EU considers the use of CRISPR to be genetic manipulation while the FDA does not. No genes are being added. The Chinese, the largest seafood consuming country in the world, evidently have few if any concerns either as the literature is full of reports of the use of CRISPR to generate animals with more desirable phenotypes. Since CRISPR is reportedly undetectable, there is a good chance that some altered strains may find their way into the market place. These animals will find their way into the market eventually, especially if this approach can be used to generate animals that outperform those produced via natural selection.

Given the rapid growth, the ability to grow at extremely high densities and the freedom of the presence of pathogens being carried over from the hatchery into production, the consistent use of the existing naturally selected animals could have a dramatic impact on the overall footprint of a given farm. Consider that in an average 10 ha, low density production system, harvesting 1 to 2 MTs per ha with 2 or slight more cycles per year is currently the norm. Growing shrimp at much higher densities in small lined ponds (less than 0.5 ha and some as small as .05 ha) with built in systems

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to remove massive organic matter loads can result in yields on the order of 50 MT per ha (or more). This approach allows much higher levels of productivity with a much smaller environmental impact. These systems are already proliferating in some areas of SE Asia and as the quality of the PLs improves we will see more of this in the future.

Highly controlled systems

Highly controlled production paradigms are increasing in number. Many different types of biofloc/recirculating system hybrids are evolving. Systems with the smallest possible footprint and greatest potential for profit is the ultimate goal. By using lines of shrimp that have been selected for the conditions present in these systems their potential can be realized. The availability of SPF animals, generated using established methods employed for terrestrial animals, having the potential to grow at daily rates that historically many farmers were happy with weekly, and the availability of PCR testing systems that allow for low cost testing already exist today.

We are seeing these types of systems develop in inner cities far from sea water. Hydroponics and aquaponics are becoming elements of some of these and high levels of automation will become the norm. Artificial Intelligence (AI) programs in combination with engineered systems will allow these to run with little human input. All production parameters will be automated. To date, thee systems have met varying degrees of success. Unfortunately today, as the point has been made, without paying attention to some very import details, like the use of broodstock that are not free of pathogens, failure is the norm. Feeding can be automated with animals being fed based on their demand and water chemistry parameters including the critical O2 levels can be as well allowing real time 24 hour a day monitoring. This reduces human error and should allow for low cost production paradigms in those areas where labor rates would make human involvement problematic.

The future of aquaculture is rosy. While I have focused more so on shrimp, the generalities apply to fish as well. Post C19 we will see a period of growth driven by increasing demand and eventually, barring unforeseen complications, a return to the 6% or more average growth well into the foreseeable future. As the industry slowly consolidates and moves toward the use of science based production methodologies, many of which are available today, the costs of production will drop and demand will continue to grow. am

Stephen G. Newman has a bachelor's degree from the University of Maryland in Conservation and Resource Management (ecology) and a Ph.D. from the University of Miami, in Marine Microbiology. He has over 40 years of experience working within a range of topics and approaches on aquaculture such as water quality, animal health, biosecurity with special focus on shrimp and salmonids. He founded Aquaintech in 1996 and continues to be CEO of this company to the present day. It is heavily focused on providing consulting services around the world on microbial technologies and biosecurity issues.
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