"Shellfish Aquaculture, a Look Outside Greece".

"Innovative Practices for Sustainable and Environmentally Friendly Mussel Culture"

A project of the Alexander Technological Education Institute of Thessaloniki, Department of Fisheries and Aquaculture, Thessaloniki, Greece.

This 2014-2015 research project is lead by Dr. Sofia Galinou-Mitsoudi and a team of researchers from within and outside the University. The project has several elements, goals, objectives and deliverables. One of which is a report on the "Status of Shellfish Aquaculture in the World". More specifically how Greek shellfish farmers play a role in the effort to feed the world. Including how the Greek shellfish farmers can do this in a responsible and sustainable manner. Mr. Daniel Barth, a shellfish aquaculture consultant and researcher from the United States has worked with Dr. Galinou-Mitsoudi on other projects and was asked to write this report. It is based on information presented by Mr. Barth at a conference in Thessaloniki in September, 2014. That presentation was titled "Shellfish Aquaculture, a Look Outside Greece". This report is a summary of that presentation information. It is not meant to be an in-depth and detailed investigation and history of shellfish aquaculture and farming or a detailed listing of facts, figures, graphs and charts restating current literature. You are welcome to do your own literature search for that kind of data. It is presented here rather as a presentation of ideas, issues, trends, opportunities and a look to the future for shellfish farming in Greece and beyond.

Having said this it is important to set the stage for the information contained here by some references and statements from several of the worlds professional aquaculture organizations.

1. The Food and Agriculture Organization (FAO) of the United Nations, Fisheries and Aquaculture Division has published a document titled, "State of World Aquaculture". It states: "…Aquaculture continues to be the fastest growing animal food-producing sector and to outpace population growth. Per capita supply from aquaculture increased from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of 6.9 percent. It is set to overtake capture fisheries as a source of food fish. From production of less that 1 million tones per year in the early 1950's, production in 2006 was reported to be 51.7 million tones with a value of US$78.8 billion, representing an annual growth rate of nearly 7 percent….According to FAO projections, it is estimated that in order to maintain the current level of per capita consumption, global aquaculture will need to reach 80 million tones by 2050….Markets, trade and consumption preferences, strongly influence the growth of the sector, with clear demands for production of safe and quality products. As a consequence, increasing emphasis is placed on enhanced enforcement of regulation and better governance of the sector. It is increasingly realized that this cannot be achieved without the participation of the producers in decision making and regulation process, which has led to efforts to empower farmers and their associations and move towards increasing self-regulation.

These factors are all contributing towards improving management of the sector, typically through promoting "better management" practices of producers…"

2. The FAO document also states: "…A wide variety of animal and plant species are produced through aquaculture: finfish, shrimp, prawns, crabs, clams, oysters and mussels; as well as seaweeds and other aquatic plants…Aquaculture produces nearly 50 percent, of the world fisheries production of 110 million tones of food fish in 2006. Half of all aquaculture production is finfish, a quarter is aquatic plants and the remaining quarter is made up of crustacean (such as shrimp, prawns, crabs) and mollusks such as clams, oysters and mussels…"
3. The World Aquaculture Society (WAS) states: "…Aquaculture will have to play an increasingly important role in meeting the global demand for fisheries products as the world population continues to expand and fisheries stocks approach their biological limits. Although world aquaculture production reached an all time high of 28.8 million metric tones valued at US$ 45.4 billion in 1997, aquaculture production will have to expand at least two fold to meet world demand for fisheries products by the year 2025. Aquaculture will also play an important role in economic and community development throughout the world as the world moves toward a global economy. The progressive development and expansion of aquaculture will be dependent on the generation, dissemination, and adoption of knowledge and technology consistent with broad, societal, national and international goals. As aquaculture production expands to meet the global demand for fisheries products, it is essential that efficient and environmentally sustainable production systems be developed and utilized."
4. The European Aquaculture Society (EAS) publication for the EU Directorate titled: "The long term economic and ecological impact of larger sustainable aquaculture" states in Section 2 "The consequences of a larger aquaculture sector": "…Sub Section 2.1.2. "Shellfish production". The general synopsis is for production growth of 30 percent by 2030, meaning an annual growth rate of 1.3 percent per year. This growth will initially come from oysters and mussels and minor species, while disease resistant oysters are bred for production purposes…It is envisaged that demand for EU shellfish products will increase, with the sector being perceived by consumers as being natural, safe and sustainable. In terms of technology, farms will become integrated and multifunctional and more production will be offshore.
5. In the United States, the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA) in Washington DC, USA states: "Marine aquaculture in the United States contributes to seafood supply, supports commercial fisheries, restores habitat and at-risk species, and maintains economic activity in costal communities and at working waterfronts in every costal State. The preponderance of marine aquaculture production – approximately two-thirds by value – consists of bivalve mollusks such as oysters, clams and mussels. Salmon and shrimp constitute most of the rest, but advances in technology and management techniques are increasing the availability of other species for the American public…"

As seen above the major molluscan shellfish being farmed are oysters, mussels and clams. For the purpose of this report and project the author is limiting discussion to these species.
China is clearly the world's leader in shellfish production by volume. Depending on who publishes statistics the countries that follow will vary in ranking depending on available data. But it is clear that Greece's commercial shellfish production ranks low on the world wide list. Greece's primary shellfish being farmed is the Mediterranean mussel (Mytilus galloprovincialis). A very small amount of oysters are farmed in Greece and essentially no clams or cockles are farmed. But the opportunity for farming oysters and clams exists and will be addressed later in this report.

A limiting factor in the commercial production of shellfish in Greece, and other countries is the lack of government support in the issuance of approvals, licenses, leases, and authorizations to use publicly owned waters for shellfish production. Permitting costs and time delays in issuing permits seriously hinders the development of an ecologically safe and sustainable shellfish industry along with economic development.

A factor that may enhance Greek shellfish production is the recognition of the quality of the products available from growers. A good program of quality assurance, health protection assurance, supply assurance and Brand development and recognition should be a high priority for government regulators, buyers and consumers.

Greece's mussel production is that of the Mediterranean mussel. The Mediterranean, Blue (Mytilis edulis) and Green Lip (Perna canaliculus) mussel species are farmed around the world. Mediterranean mussels are farmed in Washington State on the Pacific Coast of the USA. Farmed mussels are found to be of higher value that wild caught mussels. Some countries are phasing out the dredging of wild mussel beds do to potential damages to the sea beds. Thus there is a need for better farming methods using state of the art materials and equipment to foster a sustainable industry.

Globally, New Zealand is the leader in mussel production using reusable and biodegradable farming equipment. Polypropylene ropes can be cleaned, washed, dried and reused. Biodegradable cotton socking is replacing plastic materials that may end up in land fills or illegally dumped in the marine environment. Greek mussel farmers should be aware of these newer materials and government regulators should foster their uses in an effort to move the Greek mussel farming industry forward.

Seed supply for all shellfish farming is a concern for growers. This applies to mussels, oysters, clams and other species. A "wild" seed catch can work well in some areas while "hatchery" seed is preferred in other areas. Both have pros and cons to the farmer. Cost is always a major factor. If you can "catch" your own spat/seed from the wild you may be able to reduce seed costs compared to hatchery seed. But hatchery seed can be supplied year round, graded, sorted and shipped loose

or on seeded ropes and certified as disease free. All these are plus factors to the farmer.

Culture systems will vary depending on the site. These include long-line systems, floating rafts and stationary raft structures (Parks in Greece). Long-line system includes lantern nets, baskets, trays, single dropper and continuous dropper systems. In New Zealand the continuous line system is the culture method of choice. Harvest methods will vary on the system used. In New Zealand the spacing for collector ropes is 40 cm between droppers, while the spacing for grow out dropper lines is 60 cm between dropper lines. In the USA these distances can vary especially when using a floating raft system as catchment ropes and grow out dropper line in the center sections of rafts may have a limited food supply compared to lines on the outer areas of the rafts. Many times the appropriate distances between dropper lines are a direct function of available food for the mussels. Often some farmers over stock the lines hoping for increased production only to find minimal growth and stunted or misshapen mussels. The field work being done by Dr. Galinou-Mitsoudi is aimed at determining optimum stocking for grow out of mussels at locations in Northern Greece. Similar studies need to be carried out at other locations with the support of the government regulator agencies and with help from the EU in the opinion of this author.

Diversity of species can enhance production. In some countries farmers are using poly-culture to diversify their products being farmed on the same sites. This is where oysters and scallops are being farmed along with mussels. Either on the same long-lines or alternating long-lines. These may include surface floating bag and tray system or submerged bags, trays and basket systems. In the State of California in the USA a company has designed an offshore mussel farm to include oysters and scallops.

The Pacific oyster (Crassestrea gigas) and the European flat or Belon oyster (Ostrea edulis) are the two mayor species being farmed around the world. The European Flat is native to Europe and the Mediterranean. The Pacific oyster has been introduced into the EU and the rest of the world and is now the most cultivated oyster species in the world. Pacific oysters from Southern Africa have been farmed there for decades. The Pacific oyster was introduced into the West coast of the USA in the 1920's. Sub species and similar species are being farmed on almost every continent. Greek farmers should look at this as an opportunity for diversification and product enhancement. Hatcheries in Italy, France and elsewhere can be major suppliers of seed. But a caution to only source certified disease free seed should be the priority for Greek farmers.

If there is a concern that introducing a non native oyster may impact native species one should consider using only natural triploid oyster seed. This process of crossing a diploid oyster with a tetraploid oyster yields a sterile triploid oyster that will not go into spawning condition and thus yield an oyster full of high quality meat year round. The idea of poly-culture of oysters and scallops along with mussels deserves

consideration by the government authorities tasked with fostering a sustainable aquaculture industry. Economic development associated with new species creates jobs and opportunities in rural communities and leads to economic growth, in the opinion of this author.

Being able to farm and produce a quality seafood product is well and good. But without a market to sell to is it really worth doing? The "Market" made up of buyers, restaurants and consumers demand quality assurance and good products. To meet market demands the world shellfish aquaculture industry has and is developing Best Management Practices (BMP's), Environmental Code of Practices (ECP's), Best Farming Practices, disease prevention programs and farming equipment maintenance and practices. These all lead to quality assurance, sustainability and environmentally friendly production methods. The international program of Hazard Assessment Critical Control Point (HACCP) is now the standard for disease prevention in shellfish farming and product delivery to the consumer. Every farmer needs a HACCP plan and government agencies need to manage it.

Farming shellfish to produce a "Live in the Shell" product is just one goal of the industry. Every day new value added products are entering the market place. These include frozen, frozen meat only, smoked, canned, cooked / ready to eat heat and serve and other ideas. Farmers need to be open to new markets and supplying these value added interests.

"Adaptive management" – being open to these new ideas, equipment, products and markets and willing to engage in new programs is a key element in a successful shellfish aquaculture business.

For example, for many years European oyster farmers cultured the Pacific oyster to yield a medium to large nicely shaped single oyster for the raw half shell market. But consumer demographics and tastes now are showing a preference for a small deep cupped oyster such as the Kumomoto, Olympia, Shigoku and Kusshi oysters. These last two are simply a Pacific oyster cultured in a different way – flipping bags. With a Branding and marketing program these oysters command higher prices than regular Pacific oysters. Smaller sizes and higher prices are a benefit to the farmer.

Additionally in the past few years' oysters are being flash frozen with the top shell off. Shelf life is looked at in months rather than a week. USA companies are shipping thousands of frozen top off oysters to China each week. Demand is high and there should be no reason Greek farmers could not be part of this market.

Greek mussel farmers are already engaged in producing mussels for the frozen mussel meat markets. Do consider the opportunity to farm oysters and produce "Oyster meats" for the fresh market. There are far too many ways to prepare and cook oyster meats to begin to mention here. But a quick and easy way is "pan fried oysters". "Oysters and Chips" are now just beginning to be seen in the European markets but are a standard in North American markets. This is similar to "Fish and Chips" but

can be Branded and marketed to increase sales. Just marketing a seasoned breading for oyster meats would increase sales of oyster meats for the take home and prepare at home consumer. The benefit for the farmer for oyster meats is that you are only using the meats. There is no need to farm a "Perfect" shaped oyster. Misshapen oysters usually thrown away as non saleable are opened for the meats. Thus less discards and more opportunity to increase sales.

To my knowledge no one is serving deep fried "Mussels and Chips". With various seasonings these may be a competitor to Fish and Chips. It just might be a new Fast food item. Mussel meats sold fresh rather than frozen may be used in seafood chowders along with smoked mussel meats.

Greek mussel farmers may be interested in looking into diversification of species farmed and moving into the processing side of the products. It all depends on the individual's goals and vision for their business.

Poly culture along with mussel farms is just one way to diversify products. Oyster and clam culture methods may be adaptable to Greek waters in shallow areas near shore, and in protected bays and inlets. Soft and hard bag clam culture may work in Greece. Clams can be farmed using rigid plastic or soft fabric bags as proved in the USA (Washington State and Florida State). This method may be applicable to farming the native Carpetshell clam (Ruditapes decussates) as well as the native Warty Venus clam (Venus verrocosa). An introduced clam species to the EU, the Manila clam (Venerupis phillippinarum) should be considered for Greek farming practices. Hatcheries around the world can produce and supply seed for these clam species. Farmers should consider working with Greek government representatives to authorize pilot or research projects for these clams to verify the feasibility of successfully farming them in Greece. Markets for these clams include the EU, China and perhaps the USA.

Greek farmers, either as individuals or organizations should consider working with Government agencies in Greece, EU Commissions or Directorates as a way to foster encourage a successful shellfish farming industry.

No matter what shellfish species is farmed there will be waste and discarded materials, both organic and inorganic. One of the goals of this Project by the University is to foster uses for discards and waste materials. The elimination of waste materials going to landfills or unauthorized dumping is a priority. Use of biodegradable cotton socking in mussel culture is becoming the norm around the world. There is no reason why Greek farmers should not consider this. Polypropylene ropes and net materials can be cleaned and re-used, thus avoiding discarding into land fills. In some places small products are being made from shellfish discards. In the USA there are companies using oyster, lobster and mussel discards in making compost for gardening and landscape work. In some countries mussel shell is being used as cultch materials in place of oyster shells in oyster hatchery production. A recent study in the United Kingdom shows that discarded

mussel shells can be used in the tertiary treatment of waste water from municipal waste water treatment plants. It is cheaper and just as effective as high cost treatments. Pet foods and some fish food pellets are using discarded and bio-fouling materials from shellfish farms. Her too Government support for research into alternative uses of discards is important. Support for feasibility studied and small business loans for start up companies using discards can enhance opportunities and expand economic development. With some creative thinking Greek farmers can be leaders in alternative uses of discards and using environmentally friendly materials.

The results of this mussel farming research Project will be presented at future meetings and conferences. This report will be available as part of this Project. Many of the comments made here are those of Mr. Daniel Barth. Mr. Barth can be contacted by email at dbarth@localaccess.com for questions and comments.

It is my sincere hope that this summary of a presentation given in September, 2014 and the ideas, suggestions and potential opportunities expressed herein are received with an open mind. Perhaps in some small way new opportunities will open for Greek shellfish farmers.

Thank you

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Attachment A to report of Daniel Barth.

Figure 1. Simple mussel dish in a Greek restaurant.

Figure 2. Example of Greek long line mussel farming.

Figure 3. Typical double long line mussel farm in New Zealand.

Figure 4. Continuous long line mussel farming in New Zealand.

Figure 5. Bio-degradable cotton socking for mussel farming.

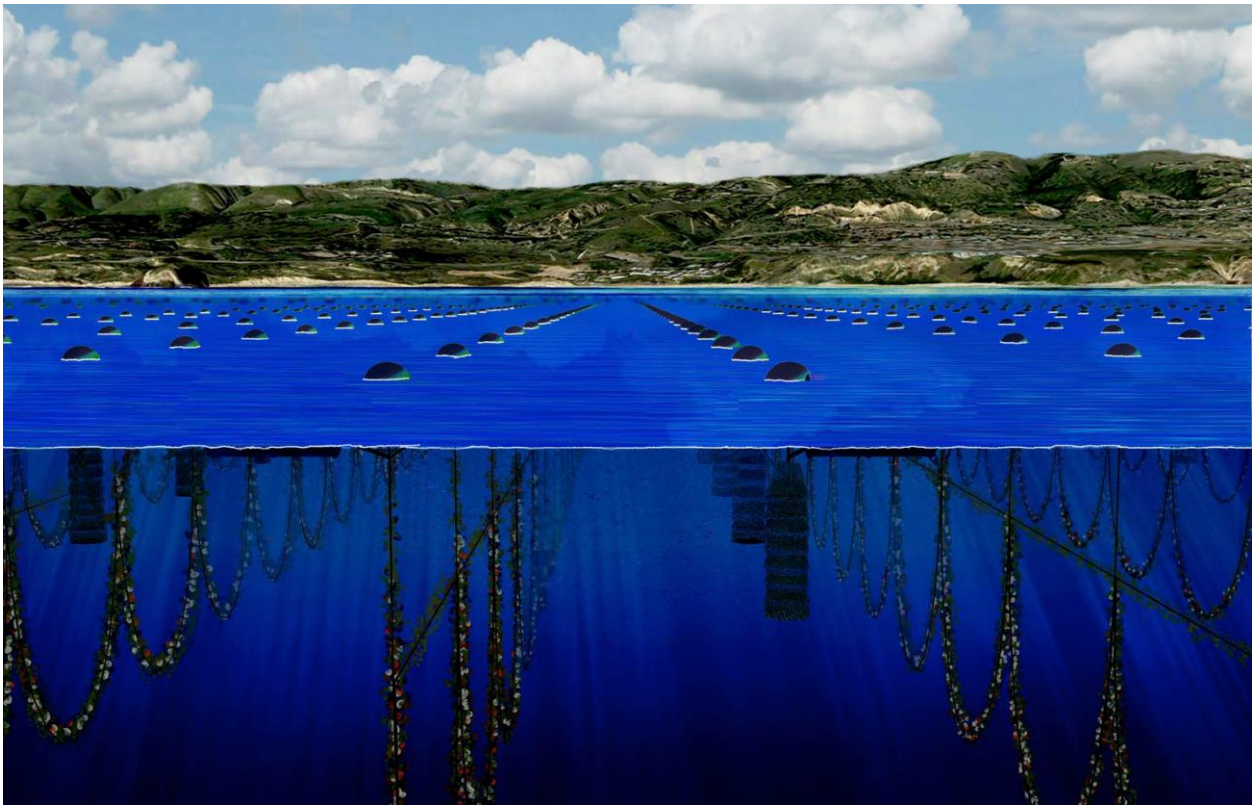
Figure 6. Polyculture of mussels, oysters and scallops in California, USA.

Figure 7. Municipal sewage treatment works using mussel shell to “polish” effluent.

Figure 8. Specialty oysters: Kumomoto Shigoku and Kusshi. An American and Canadian product.

Figure 9. Shucked fresh oyster meats ready for jars and shipping. A USA product.

Figure 10. Seed clams of European carpet shell (Ruditapes decussates). An American product available to Europe.