

# EVOLUTION THROUGH INNOVATION IN AQUACULTURE: A CRITICAL REVIEW OF THE HELLENIC MARICULTURE INDUSTRY (GREECE)

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## **ABSTRACT**

Marine aquaculture in Greece is a relatively new industry based on the culture of aquatic species such as the Mediterranean sea bass (*Dicentrarchus labrax*), Gilthead sea bream (*Sparus aurata*) and the farming of the Mediterranean mussel (*Mytilus galloprovincialis*). In the early 1980's, the results of R&D were applied to develop pilot semi-academic commercial farms. Such farms were gradually moved to the industrial scale of today, giving approximately 80-120,000 tons of finfish and up to 25-35,000 tons of mussels in annual basis. The problems encountered during the adaptation of innovations to the production and management of this blue revolution is critically discussed, from the early developmental phases up to the current crisis phase.

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## **RUNNING HEAD**

Innovation in the Hellenic mariculture

## **KEY WORDS**

Sea bass, Gilthead sea bream, Mediterranean mussels, mariculture sector, innovative development, Greece.

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# EVOLUTION THROUGH INNOVATION IN AQUACULTURE: A CRITICAL REVIEW OF THE HELLENIC MARICULTURE INDUSTRY (GREECE)

## 1. INTRODUCTION

Marine aquaculture in the Hellenic coastal waters has been introduced in the early 1980's not only as a high risk activity, but also as a well promising tailor made sector to the national coastal resources and the marine environment of Greece (Frentzos, 2013). EU structural/operational programs, suitable environmental and climatic conditions, coastline morphology, available start-up technology and know-how from Japan, France, Italy and Norway (Stephanis, 1995a,b) and the emergence of a small but critical mass of skilled scientists and prospective entrepreneurs were critical during the early developmental phase. Currently, the Hellenic sector dominates the Mediterranean mariculture industry, largely based on the production of the euryhaline finfish species such as the Mediterranean sea bass (*Dicentrarchus labrax*), the gilthead sea bream (*Sparus aurata*) (Theodorou and Charalambakis, 2001) and the Mediterranean mussel (*Mytilus galloprovincialis*) (Theodorou et al., 2011a).

Both in finfish and mussels, the continuous inoculation of innovations into the production process from the early stages (1980's) led to rapid expansion of the business development (Theodorou, 2002; Theodorou et al., 2011a). However, even after the booming of the sector, Greece still remains a hostile business environment, particularly for new initiatives (e.g. spinoff companies) mainly due to bureaucracy and absence (until 2011) of spatial planning and mid-long term sectoral strategic plan. This is similarly evident, in most well-established industries, where several and unexpected problems are emerging when developing innovative projects. The aim of the present work was to critically review the achievements of the mariculture sector, showing in parallel the major milestones and shortcomings of this evolution.

## 2. MATERIALS AND METHODS

Several publications demonstrated the growth and technological trends that led to the development of the Mediterranean aquaculture from the research laboratories to the industrial level (Stephanis, 1995a,b; Theodorou and Charalambakis, 2001; Theodorou, 2002; Theodorou et al., 2011a). In the current study, an effort was made to review and combine the results of these achievements for both finfish and mussels at a national level and critically discuss the problems and constrains.

It is generally recognized that there is variability of data on Hellenic aquaculture mainly due to: a) under-reporting (i.e. on-growing production volumes and values); b) production quantities and values for hatcheries and nurseries reported are likely to reflect the total production of juveniles rather than sales; and c) missing of data and methods used for the approximation of missing data (STECF, 2013). The comparison between facts and the figures given by several sources showed a wide range of values that has been criticized by several previous reports (Barazi-Yeroulanos, 2010; STECF, 2013).

Given that inefficient data-collecting systems are not a Hellenic phenomenon in fishery statistics of the European Union (EU) (The Economist, 2008; Tsikliras et al., 2013; Moutopoulos & Koutsikopoulos, 2014), we tried to identify basic trends. Combined data from several sources were used such as national (Greek National Statistic Service; GNSS) and international authorities (Commission of European Communities, 2009; FAO, 2006-2014), as well as data from fish farmers associations [Federation of European Aquaculture Producers (FEAP) and Federation of Greek Maricultures (FGM)] (Theodorou, 1995; Hough et al., 2000; FEAP, 2013). In addition, personal guided interviews for estimations by experts and professionals were followed in certain cases of limited data availability. Finally, critical scientific (Theodorou, 2002; Theodorou, et al., 2011a) and grey (Protopappas and Theodorou, 1995) literature review and synthesis on previous publications was essential in order to cross check facts and figures related to the industry's growth.

### **3. RESULTS**

In order to understand the stages of passing from R&D results to the industrial-scale level, the proposed distinction by Stephanis (1995a) and Theodorou (2002) for sea bass/sea bream and mussels (Theodorou et al., 2011) was followed, with the addition of a last phase covering the current economic crisis period. Major innovative milestones in the evolution of the Hellenic mariculture sector are presented on Table I. These phases are generalized and summarized as follows:

EVOLUTION THROUGH INNOVATION IN AQUACULTURE: A CRITICAL REVIEW OF THE HELLENIC MARICULTURE INDUSTRY (GREECE) (Republication)

**Table I.** Major innovation milestones and projected achievements in the Hellenic mariculture sector (at administration, company and market levels and specifically in fish hatcheries, on-growing farms and mussel farms) during 1980-2030.

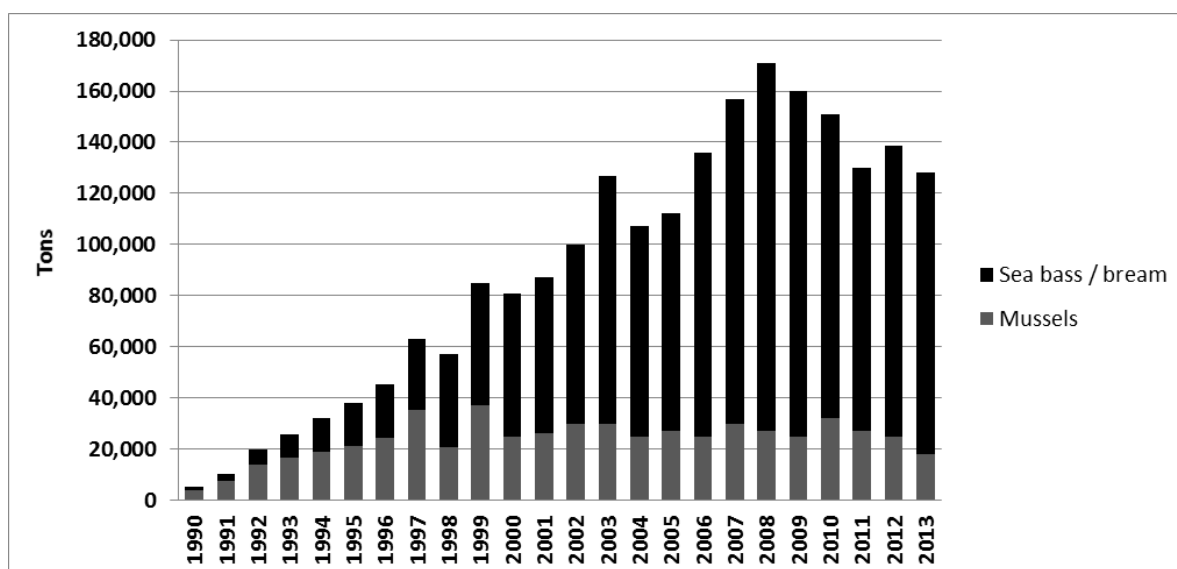
Industry Structure	Innovation									
Mediterranean sea bass/sea bream	Operating level	Administration		EU Structural Support Funds	Institute of Marine Biology of Crete	Federation of Greek Maricultures (FGM)	EU funded operational program "Fisheries 1994-1999" and EC "PESCA Initiative"		Federation of Greek Maricultures joined the Federation of European Aquaculture Producers (FEAP)	EU funded operational program "Fisheries 2000-2007"
		Company	First marine fish farming company established					First company in Athens Stock Exchange	ISO certification	Code of Conduct/ Code of Practice
		Market			Italy	France		Germany, Spain	HACCP	USA
	Hatchery	Livestock								
		Equipment		Surface water supply	Open water circulation	Borehole water pumping				Semi-closed & Closed Recirculated Systems
		Fish Health				Skimmers to avoid swimbladder malformations				Ozonization
		Feed		Live food mass production (algae-artemia-rotifers)	Artemia & rotifers artificial boosters					
	On-growing	Livestock	First marine farm						New species (ie, sharp snout sea bream, Pagrus, Pagelus, etc)	
		Equipment	Wooden cages 6X6m	Manual feeding		Automatic feeders	Metal rectangular cages		Circular plastic cages	Use of cranes
		Fish Health/Quality							Packing stations	Fish vaccination
		Fish Feed				Normal pellets (Fat:8-12%) FCR:3.5	Introduction of extruded pellets (Fat:16-20%)	FCR:2.7		
	Mussels	Whole process	Administration							Marine Toxins Laboratory
Equipment			Hanging Parks		Floating long-line			Boats up to 14 m long	Packing stations/Exportation centers	Star wheels, French type grading machines
Market					Raw pergolaris					Graded packed 10kg bags
		1980	1985	1990	1995	2000				



**1. R&D phase.** During this phase (1965-1979), embryonic Mediterranean marine finfish culture was initially established in Italy and France in the early 1970's, quickly diffused to Spain, and by 1980, was almost Mediterranean-wide. Similarly (from 1950 to 1977), suspension mussel farming systems were first established in Italy and France, and quickly expanded to Spain, U.K. and Ireland and until the 1980's they had expanded over almost the entire Mediterranean (Danioux et al., 2000). Early efforts in the early 1970's to cultivate mussels in Greece were carried out by using hanging parks, and were restricted in few sites, close to major cities [i.e. Athens (Gulf of Saronikos) and Thessaloniki (Gulf of Thermaikos)]. This phase partially overlaps with the global post-war pioneering in aquaculture development (1950-1970) and particularly with the period of uncontrolled aquaculture expansion (1965-1975) (Nash, 2011).

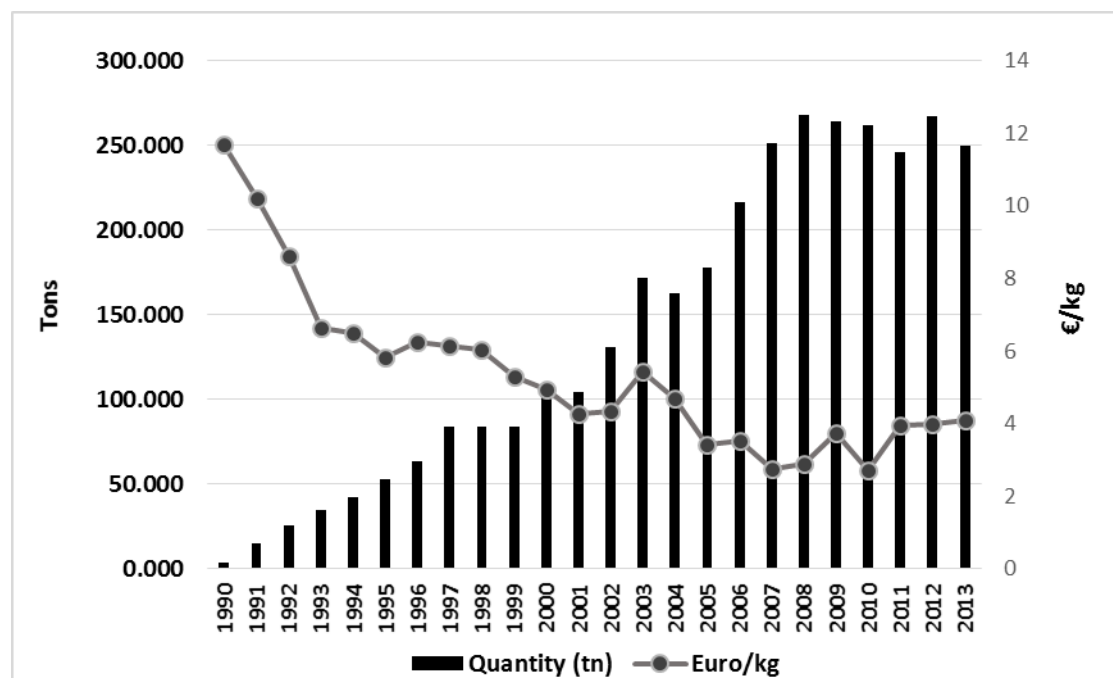
**2. Pre-development phase.** During this period (1980-1990), the first pilot-scale fish farms, sometimes quasi-governmental, were established and research priorities were focused on transcending basic production problems (Stephanis, 2013), such as fry production and fry quality problems, nutrition and increased mortalities in the grow-out phase. EU funding and the strong support from the Agricultural Bank of Greece through loan offers and insurance coverage played significant role in supporting this high risk innovative activity which was unknown as a business at that time (Stephanis, 1995a; Christophiligiannis and Theodorou, 1995; Theodorou et al., 2003; Theodorou and Tzovenis, 2004 a,b; Theodorou et al., 2010c). At this stage in the shellfish sector (1985 to 1990) the first pilot-scale long-line mussel farms were established, creating an opportunity for mass expansion of the activity in Greece.

**3. Development phase.** During this period (1991 to 1994) sea bass and sea bream production problems of fry production were largely solved and production was easily up-scaled in a massive way (Figure 1).



**FIGURE 1.** The total annual production of Mediterranean aquaculture species (European sea bass/sea bream and mussels) in Greece reflecting the application of the technical innovations in the marine farming process during the developmental phase (early 1990's) (sources: FEAP/FGM 2013; GNSS 2013).

The doubling of the produced quantities of both farmed species to the market (i.e. production mountain) induced in 1993 the first price crisis in Greece (Figure 2).

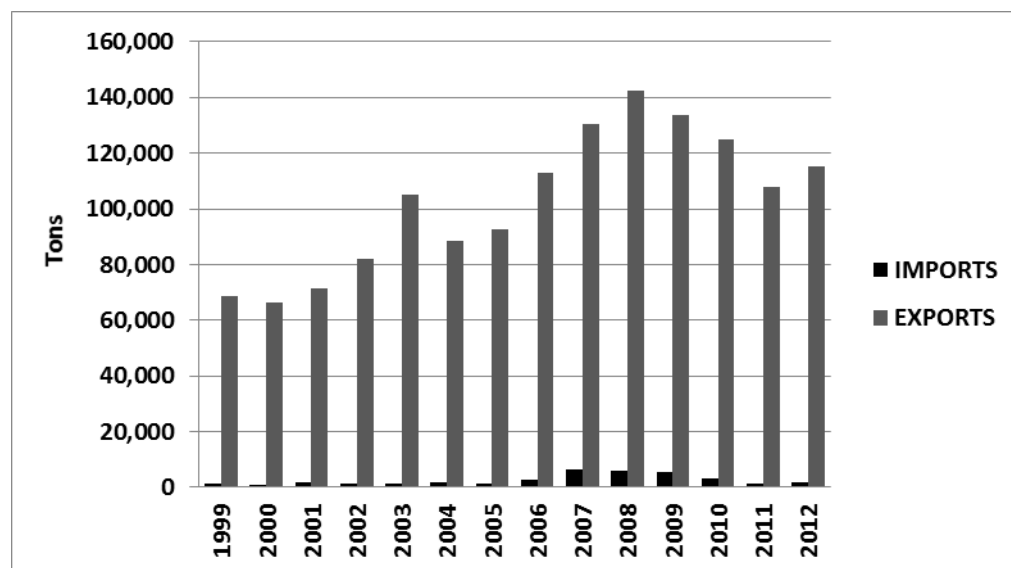


**FIGURE 2.** Production and annual average ex-farm prices (€/kg) of European sea bass and sea bream in Europe (sources: FGM, FEAP).

Similarly, mussel farming, which expanded from 1991 to 2000, focused on production escalation. At the end of this period, serious toxic incidents due to Harmful Algal Blooms (HABs) (Koukaras and Nikolaidis, 2004; Economou et al., 2007) necessitated an extended harvesting ban period and accordingly led to the first serious production disaster. This stimulated the introduction of new “French type” grading equipment and the construction of larger vessels in order to handle larger volumes of mussels at a shorter period of time and accordingly prevent losses prior future harvesting closures. Consequently, the National HABs Reference Laboratory was established in 1999 to monitor the bivalve shellfish harvesting areas (Theodorou et al., 2011a).

Overall, in both finfish and mussels, research, public and industrial priorities focused on production escalation without investments in marketing. Moreover, technical innovations such as feeds (e.g. formulated and enriched diets for hatcheries, fish feeds for the on-growing farms), fish veterinary services (e.g. medicines, vaccines) and equipment (e.g. cages, nets, counters, graders, automatic feeders, etc) were directly provided to the marine farms by the major industry feed suppliers supported in most cases by research institutions.

**4. Maturation phase.** During this phase (1995 to 2008 for finfish; 1995-present for mussels), profit margins of the main farmed fish were strongly compressed, and although the trade balance continued to rise (Figure 3), ex-farm prices decreased (Stephanis, 2000), inducing extended periods of price collapses (1999-2002 & 2007-2008) (Figure 2).

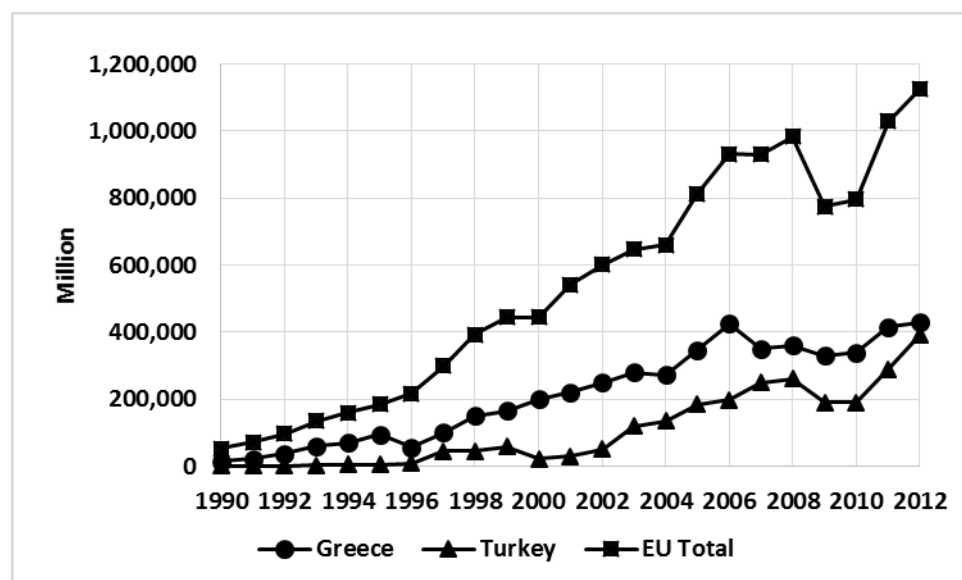


**FIGURE 3.** Trade balance of the main marine cultivated/farmed products (European sea bass/bream and mussels) in Greece (sources: FEAP/FGM 2013; GNSS 2013).

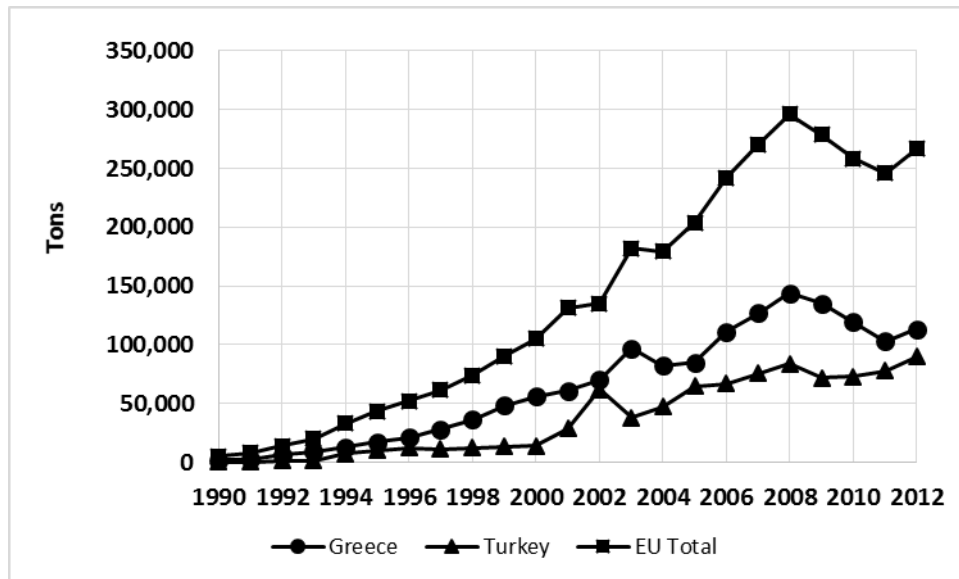
New aquaculture strategies were applied included concentrating production around large companies, or groups of companies (with associated economies of scale intended to lower the production costs) (Stephanis, 1995b, 2013), diversification into new promising farmed species (Pedini, 2000) and improvement of product quality (Harache and Paquette, 1996). Given that most of the major technical problems were already solved and mass production achieved, innovations played a secondary role for the competitiveness of the sector, according to the producers' approach (European Parliament, 2009). However, major contributions were also made for example by the application of novel vaccine technology, the replacement of wooden and metal cages by versatile circular plastic cages able to withstand higher wave and current forces, the use of automation systems either in feed distribution and the use of cranes for harvesting and on-farm day-to-day activities. The adoption of semi-closed and closed-recirculated systems in the hatcheries, significantly improved larval quality and the operational efficiency. Significant amount (50) of research and development (R&D) projects regarding aquaculture (marine & freshwater) started to be carried out in Greece during that period (2005-2010). However R&D efforts were far behind other peri-Mediterranean countries with R&D tradition and established mariculture sectors such as Spain (121), Italy (120) and France (100). Most of the research was carried out in Universities and National Research Centers, while the majority of the projects were funded by public resources [national and EU, i.e. the Financial Instrument for Fisheries Guidance scheme revised by the European Fisheries Fund, and the 7th Framework in Research Training and Development (RTD) Program]. The direct investment of the industry in research was low, while there was a lack of strong involvement of the industrial stakeholders in consortiums (when not compulsory) (Rigos, 2013), partially explained by limitations in scope and resources of the funding schemes and shortage of private and bank finance for aquaculture development and particularly innovation (European Parliament, 2009). Research tasks were

focused on the systems' technology, environmental interactions and production optimization. The second most important research task was the biological life cycles of the farmed or candidate species, including nutrition, larval rearing, reproduction, health, welfare and genetics. Socio-economics were also recognized as a research necessity to solve problems regarding the coastal zone management, the consumers' safety and the product quality management. However, despite the limited domestic shellfish research (AQUAMED 2013; Rigos, 2013), the mussel cultivation sector (from 2001 to present) has been benefitted by new innovations. These have been introduced to make offshore systems reliable with focus on lowering production costs and achieving economies of scale (Theodorou et al., 2010a,b; 2014a). The production is also controlled by few large family companies with direct market access.

**5. Economic crisis phase.** Currently, fish farms in Greece can be roughly divided according to their annual production in small (<300 tons), medium (300-1200 tons) and large (groups of companies >1200 tons). In this last phase (2008-present), the finfish sector is characterized by production recession, minimal or negative profit margins, struggling for financial liquidity, debt problems, restructuring and merging efforts and efforts to enter new markets, particularly in eastern Europe (i.e. Russian Federation and Ukraine until mid 2014). Moreover Strong competition from Turkey (competitive innovation advantage of the Hellenic marine fish farming was surpassed by the Turkish industry which doubled the farmed output within less than a decade, partially based on financial, technological and labor inputs from Hellenic aquaculture companies; see Figures 4 and 5) and the first critical steps towards a country-wide application of spatial planning are expected to shape the future profile of the sector.



**FIGURE 4.** European sea bass and sea bream juvenile production (Source: FGM, FEAP).



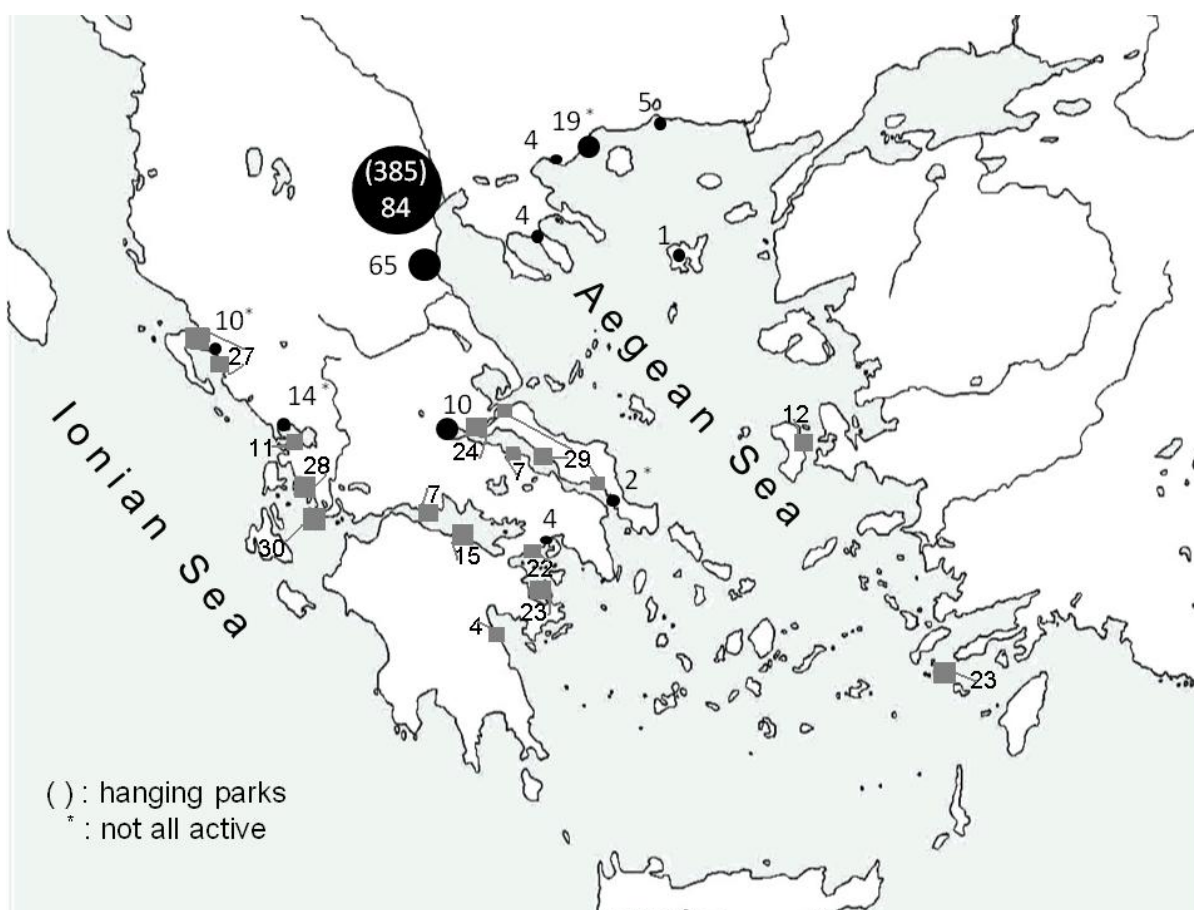
**FIGURE 5.** European sea bass and sea bream production (sources: FGM, FEAP).

The Common Spatial Planning Framework for Aquaculture (Common Ministerial Decision No 31722/2011, FEK 2505 ratified on 4 November 2011) aimed in theory to provide guidelines, directives and criteria for the spatial structure, compatibility, organization and development of the aquaculture sector and to secure environmental protection and competitiveness. Moreover, it specified guidelines for each type of aquaculture activity (finfish mariculture, shellfish farming, freshwater and extensive farming in estuaries/lagoons), including suggestions for further legal and administrative actions and to the formation of an action plan. The main targets of this framework were to:

- a) Exploit the competitive advantage of the Hellenic seas and to contribute to the local, regional and national development.
- b) Involve environmental-friendly policies and enhance natural resource protection.
- c) Secure the necessary space for sector development (through the establishment of new farms and modernization, relocation or expansion of the existing ones), as well as the application of new technologies and culture/farming methods.
- d) Increase the national aquaculture production, the diversification of species and the support of the production process through better safety and quality standards.
- e) Turn to organic aquaculture, innovative technologies and experimental culture.
- f) Support farm zoning/concentration in specific areas against isolated farm sitting.
- g) Regulate the competitive relationships between antagonistic users of the coastal zone and inland waters (e.g. tourism, professional fishing, maritime) and promote complementarities particularly in remote or less developed areas through job creation and multi-functioning.

- h) Support the economic sustainability of the farms by creating a stable developmental framework, specific rules and coordinated policies.
- i) Reduce licensing bureaucracy for new farms.
- j) Protect public health and promote better welfare of the farmed stocks.
- k) Adapt the national developmental policies of the sector to the new challenges of the aquatic product markets, to the Common Fisheries Policy of the EU and other relevant policies.

This framework identified five categories of areas (Figure 6) according to farm concentrations: a) particularly developed areas requiring improvement, modernization of farms and infrastructures and environmental upgrading; b) areas with significant scope for development; c) remote areas with significant scope for development; d) areas with particular environmental sensitivity requiring the adaptation of the existing farms to specific characteristics of the aquatic environment; and e) suitable remote, borderline, or close to large urban or touristic areas where farm concentration is not allowed due to competition with other users or environmental sensitivity.



**FIGURE 6.** Major concentrations of sea bass/sea bream (grey blocks with bold numbers) and mussel farms (circles with non-bold numbers) in Greece.

It should be noted at this turning point that the overleveraging process particularly of the large companies was the outcome of several factors such as (Perdikaris

and Paschos, 2011): a) artificial price recession by large companies towards smaller farms, during the aggressive and direct purchasing phase (after 1995). Accordingly, although the Hellenic mariculture sector controlled and exported the majority of sea bass and sea bream production volumes in the Mediterranean (Figure 5), it was practically unable to reverse the established trend of low ex-farm prices; b) cheap money earned from Athens stock exchange market during the late 1990s' which apparently boosted the sector. However these profits were not efficiently invested in the production process by the major stockholders of the large companies as the total cost of the scaling up through mergers and acquisitions was underestimated and c) instant access to bank loans with very low interest rates during the 2000s' which was the mainstream option for medium and large companies with debt problems already present; This period was generally characterized by loose economic sustainability assessment of the private sector by the banking system reflecting a loan-dependent growth cycle of the economy.

Today, Greece is a world production leader of the Mediterranean marine finfish species producing approximately the 30% of the world production of sea bass and the 50% of sea bream (FEAP, 2013). Marine farming in Greece sustain approximately 15,500 jobs (12,000 in fish farming and 3,500 mussel cultivation), mainly in rural and isolated areas, while another 5,000 more jobs were generated in supporting/peripheral activities (Theodorou et al., 2011a; Stephanis, 2013). The rapid expansion of the marine farming in Greece due to the main technical innovations in the developmental phase (1990's) and subsequently in the maturation phase is demonstrated in the Figures 1, 4 & 5. In 2008, the Hellenic production of sea bass/sea bream raised up to 140,000 tons which in the next four years balanced between 100,000-120,000 tons. In 2012, marine fish farming was the leading exporter sector of Greece with 500 million Euro export value, representing 85% of the domestic aquaculture production (FEAP, 2013). The rapid growth of sea bass/sea bream culture mainly occurred due to the increasing fry production of continuously improved quality in the hatcheries and the introduction of new on-growing technologies (cages and feeding systems, extruded fish feeds), while the significant progress in mussel farming was mainly based on the wide adoption of long-line systems and the use of bigger vessels (15–20 m long equipped with star wheels, loaders, mechanical French-type graders, and packing machines). These achievements have an effluence on the national trade balance of the country, as the exports exceed by far the imports in terms of volume (Figure 3).

#### 4. DISCUSSION

Generally, in the early stages of the industry's life-cycle, the entrepreneurial technological regime dominates innovation and the entry process is favored. Accordingly, innovation occurs within small companies, but mortality is high and selection severe. Later in the mature era of the life-cycle, a routinized technological regime dominates. Typically innovation occurs in the R&D departments of large oligopolistic firms which have a longer economic life than small companies in the entrepreneurial regime (Kougias, 2011). In fact, small producers, usually family businesses locally oriented, were very reluctant to new ways of doing things as they were familiar to the traditional working model and they had limited opportunities to invest in innovation, unless they had a direct benefit. On the other hand, vertical intergraded companies representing the large producers followed by the medium-scale companies (usually represented large on-growing farms) were eager for innovations in order to overcome technical problems and achieve better levels of optimization in their production process. The close cooperation between them and the suppliers led to the identification of possible solutions to technical problems related to the development of new products (e.g. species-specific fish feeds and production of extruded pelleted feeds). Within the above context, the suppliers were motivated to invest on R&D collaboration with research institutions. The new innovative products were tested in situ and at industrial scale, providing them with a competitive advantage compared to the rest of the farmers (European Parliament, 2009).

R&D expenditures are probably the most significant factor of a company's innovative progress. However, serious investments in R&D by the mariculture sector in Greece was either ignored as risky or never considered as a top priority (when formal R&D departments exist). This can be attributed mainly to the long-term pay-back nature of R&D and the allocation of financial resources towards production enlargement, instead of product quality and diversification. For instance, the main R&D projects involved research institutions and large aquaculture companies were related to the domestication advancement through genetic selection of sea bream (BRIDGE-MAP EU - Q5RS-2000-01797 project) (Anonymous, 2004) and sea bass (BASSMAP pilot study; Chatziplis et al., 2007) and occasionally related to the development of new diets. Despite the explosion in the knowledge basis of both academia and industry, there are weak bonds between research institutions - a common non surprising practice in Greece (McKinsey and Company, 2012) and a) the challenges of the industry; b) the practical applications needed to be tested in industrial scale and c) the sharing of the generated knowledge between the stakeholders. Overall, the number of firms reported R&D activities in fishing, fish farming and related service activities already decreased by 50% from 2004 to 2008 (Kougias, 2011). This could be explained by the fact that technological activity became part of the routinized processes in mariculture.

As the cost of innovation is high and the research results of the common developmental priorities of the Mediterranean producers exceeds the national level, the research has been funded and coordinated at a European level, involving both academia and research laboratories of different countries and

companies (European Parliament, 2009). The sharing of the top class aquaculture research infrastructures in Europe through the AQUAEXCEL network could be a catalyst to achieve the research priorities of the Hellenic Aquaculture. For this purpose, there is a strong collaboration between stakeholders at European level (supported by the EU FP7 Supporting Action "AQUAINNOVA") expressed through the development of a European Aquaculture Innovation Platform (EATiP) which is locally connected to the Hellenic Aquaculture Technology and Innovation Platform (HATiP). This working framework (EATiP, 2012), aligned the vision of the industry's new model growth for a sustainable natural food production to meet consumers' demands (Barazi-Yeroulanos, 2010, 2013; Stephanis, 2013; FEAP, 2013, 2014) with the current research targets of the academia (i.e. technology management, animal husbandry and welfare). As a result, it is expected that technology enhancement suitable to produce innovations (Theodorou et al., 2011a;b; Blancheton, 2013; Lane, 2013; Rigos, 2013) will boost the competitive advantage of the country's leading industry (McKinsey and Company, 2012).

As in any new innovative activity, there is a problem of legalization of the actions that has to be taken. Obviously one of the major problems in Greece was the lack (until 2011) of spatial coastal planning and this generated confusion over the use of space among competitive users such as tourism, coastal fisheries and urbanization of the coastal zones (Kochras et al., 2000; Zanou and Anagnostou, 2001; Zanou et al., 2005; Theodorou et al., 2011; Konstantinou et al., 2012). Due to the lack of spatial planning for aquaculture, subsidies of the European Fisheries Fund (EFF) were not granted for 2010 and 2011. During 2011, a special framework for aquaculture spatial planning came into force in Greece and the EFF grant approvals were normalized during 2013 (STECF, 2013). This legal context although valuable for future planning of the sector, it is stringent during the implementation process, requiring the official formation of managing companies in the areas of the categories a-d, in order to prepare the file for final zoning declaration via individual Presidential Decrees. This process is practically time-consuming and costly and requires the full commitment by all the involved stakeholders, public administration and local communities.

The basis of the licensing system for the cultivation of both finfish and mussels in Greece was first described in Papoutsoglou (2000) and Theodorou (2001). Although the codification of legal documents on aquaculture in Greece have not been finished yet, the licensing process was recently (August 2014) reviewed and the jurisdiction was passed almost exclusively on the eight regional administrations (i.e. to one-stop-shop offices); however these changes are expected to marginally reduce the time needed for the establishment of a new farm mainly due persistent bureaucracy (e.g. given that a company needs at least 2-3 years to get a license for the mainstream farmed species such as mussels, sea bass/bream, it takes much more time to try other new but well promising candidate species such as clams, pacific oysters or tuna). Accordingly, other countries also with competitive advantages such as Turkey, managed to double production within a decade (Figure 4) and to exert strong competition to the Hellenic products for the same market (FEAP, 2013). Environmental licensing was also updated by a) removing the preliminary environmental approval process; b) introducing the application of a carrying capacity for calculating the

maximum allowable production volume of the farms (through a debated mathematical equation); c) the need for water use license (that recently restricted only to the land-based farms by the Law No 4282/2014 (2014)) as imposed by the realization of the Water Framework Directive 2000/60 (Beza et al., 2008; Karakassis et al., 2013; Dimitriou et al., 2012; 2015); d) the obligation to comply with the EC Directive 708/07 concerning the use of alien and locally absent species in aquaculture and e) the need of CITES certification for certain threatened species. Although the above changes are expected to modernize the licensing system, it could also extend in many cases the time of leasing and permit processes and moreover it is expected to block the importation of commercially valuable alien species of aquaculture importance such as sturgeons, Manila clams, pearl and Pacific oysters. Moreover, most changes concerning the organization and function of the farms (e.g. spatial changes within the farm site or minor relocation, addition of new candidate experimental species, replacement of cages with different dimensions or even equipment such as nets of different heights) need to be included in the environmental licensing documents and those of spatial interest need the approval of the Regional councils. On the other hand, one of the most important changes was the unification of the leasing with the permits documents. Currently, it is a common notion that the entire licensing system should move towards further simplification and has to be further modernized taking into account the new opportunities for development.

At this point it should be mentioned that contrary to the high levels of official unemployment that it rose to 26% during 2014, the total employment in aquaculture decreased only by 8% (2011) mainly due to mergers and acquisitions and the management reengineering of the marine finfish sector (STECF, 2013). The leading position of the country worldwide is a result of parallel developments in the human resource skills and domestic technology (i.e. cages, nets, fish feeds). Technical know-how has been also exported together with the Hellenic business ventures to the Arabic Gulf countries, Spain, Turkey and beyond. However, these achievements could be jeopardized under the pressure of the current crisis (Perdikaris and Paschos, 2010), unless efficient policies and additional support (economic, scientific, technological, legislative and promotional) are implemented. At the same time, the industry needs to radically reform itself and re-set its goals through a process of balancing its economic losses. Furthermore, research on environmental issues, health and welfare, nutrition and sustainable feeds, species diversification, quality control and traceability, knowledge management and dissemination (Rigos, 2013) is urgently needed, in order for the sector to evolve in the next post-crisis phase as a science-based industry.

Ache et al. (2007; 2013a) demonstrated that the recent global aquaculture growth (1995 - up to day) induced several innovations such as logistics, packaging, processing and product form developments into the entire supply chain to meet the requirements of the industry. In contrast to the salmon and shrimp farming sectors, which they first developed the market and then increased the supply, the Mediterranean farmed species, have not shown marketing innovations to create demand growth, despite that they are produced in much lower quantities. Accordingly, the entire productivity growth is characterized by lower prices and

pushing more fish into the same markets. It should be noted that the extended credit period of the past served as a contributory factor to continued increase in production without corresponding investment in marketing (Mendrinou and Bostock, 2009). However, the high demand for aquaculture products and the need to be stimulated and promptly preceded by the supply of new products was early identified by the sector. Strategic planning for marketing development included image creation and message selection, promotional actions for the sector and the products, within the wider context of product differentiation and species diversification, quality certification, eco-labelling, pre-packing, product ID, company image and identity and awareness and education (Papageorgiou, 2000). However, these proposals were applied circumstantially without serious and organized efforts either by the private sector or by the public organization for export promotion. Organic aquaculture is a case of promising niche market-based initiative/product differentiation strategy able not only to bypass price recession in the Hellenic mariculture sector, but also to change established attitudes towards the natural environment (Perdikaris and Paschos, 2010). Available data suggest a production of 800–1000 tonnes of sea bass and sea bream during 2008 with mean ex-farm prices of €8–10.5 per kg and retail prices of €15–24 per kg for both species (bass and bream). Moreover, the legislative framework for the organic aquaculture in Greece was officially put in place since 2010 (No 95767/6.8.2010 Ministerial Decision, ratifying the relevant EU Directions 834/07, 889/08 & 710/09).

Significant differences in drivers for private and public companies also exist. Larger companies quoted on the Athens stock market may have been driven by targets for revenue growth to increase share value rather than focus on annual profits which tend to characterize private enterprises (European Parliament, 2009). The result of this practice is the continuous losses through the sales that direct to the negative balance sheets and overleveraged most of the companies. In terms of the sector, this has been observed as an internal competition between large and small producers (H Kathimerini, 2014). Price collapses struggled small farms and these were determined as ways to be acquired by the larger ones or to bankrupt. On the other side, companies with high stock available complaint that limited liquidity of small and sometimes big producers direct them to push into the market several quantities of fish under the production cost and they drive the market to disaster as they lose exponential amount of money. In reality, the inadequacy of the major players to set up a common market policy and an organization to coordinate the marketing and to promote the sales world-wide, creates several crisis' episodes to the sector and high debt leverage.

Concerning the mussel sector which is an extensive culture, it is totally dependent on natural productivity and the limited space availability leads to marginal profitability. These factors could explain the traditionally lower banking support compared to the finfish sector. Consequently, as the sector is less exposed to debts, it shows higher resistance to the crisis by continuing to export mussels (Theodorou et al., 2014a,b). Nevertheless, restructuring is urgently needed in order to improve its profitability. Such case is the establishment of the first Organized Area for Aquaculture Development (OAAD) during 2014 in Pieria (Northern Greece), giving the opportunity to the local producers to achieve the benefits of scale and compliance with the veterinary and environmental

legislation. Furthermore, the new EU Regulation No 508/2014 intends to mitigate the industry's vulnerability that also affected by extreme weather and increased disease incidents due to the climate change in the Mediterranean (Rodrigues et al., in press). The new rules aim to cover the gap of the inadequate/lack of insurance policies (Theodorou et al., 2014b) by compensating the losses through the financial support of the European Maritime & Fisheries Fund.

Greater availability of sector performance data would assist investors to make more realistic projections and financial institutions to better evaluate specific company prospects. Moreover, the access to finance is critical and detailed business plans about the industry performance are crucial in order to access financial resources and R&D (European Parliament, 2009). Credit absence and rising financial costs are forcing the Hellenic finfish mariculture sector to further concentrate. For the same reasons, production volumes are not expected to increase significantly in the near future and capital investment is expected to decline. Rising financial, energy and fish feed costs are expected to further deteriorate the economic performance of Hellenic aquaculture. In the long run, in order for the marine finfish aquaculture to expand and compete into the global market, research and innovation is crucial. Production cost reduction and production technology of new species needs to be addressed by research. Research funding for substitutes of the costly raw materials in fish feeds, alleviation of technological constrains mainly for new species and improvement of culture techniques will drive the expansion of the sector (STECF, 2013).

Hatchery production development was reduced after 2008 partly due to lower demand, i.e. the closure of many small and medium sized companies, reduced consumption or demand for juveniles. More importantly, most of the reduction in juvenile production was decided on a voluntary basis by the larger companies, recognizing the overcapacity and overproduction of 2007. It is likely that there will be further hatchery closures through consolidation in the future due to the sector's crisis (Barazi-Yeroulanos, 2010). The current hard economic position of most medium-large size farms in Greece and the overall macroeconomics of the sector suggest a differential response to the crisis. Many family-run, small-size farms were not severely exposed to debts in the past and they seem to be better adapted to overcome the current crisis era. This could be attributed to the close control of the production process, the limited overheads and wage costs and the ability to sell the available volumes particularly during the high-price periods (mainly from December to June). Large-scale farms have the advantages given by the economies of scale and vertical integration (fish feeds and equipment manufacturing, fry production, on-growing, processing and exports, infrastructures). They proved rather vulnerable to the intense crisis environment mainly due to financial mismanagement, targeting to production escalation instead to product quality and marketing and overlooking of the site production level management; however they are currently in a process of re-structuring with the active involvement of potential new investors, banks and the public sector. On the contrary, medium-size farms are severely impacted by the crisis, being unable to gain most of the benefits of the small and large size categories. It seems that the crisis phase will radically transform the industry; however the final outcome is not yet known.

Aquaculture as an innovative primary production sector must be positioned at top national priority as Greece has the competitive advantage of suitable environmental conditions and morphological coastline structure (Frentzos, 2013). Innovation is led by the entrepreneurship (Aspelund, 2013), usually outside the sector. Innovators may not directly be evolved with the production process which is the core business of the aquaculture companies (European Parliament 2009). For this purpose the establishment of a suitable business environment for start ups, the provisional resource availability for funding support of spinoff companies and pilot innovative projects (e.g. acoustic conditioning sea ranching (Zion and Barki, 2012); farmed based stock enhancement for the conservation of endangered marine species (Katsanevakis et al., 2015; Theodorou et al., 2011b;2015) has to be taken into account (STECF 2013). Recently it is widely recognized that the stagnancy of the industry is not only a domestic phenomenon but rather a Pan-European reality. Despite that global rate of aquaculture growth was 8%, the EU rate of total aquaculture growth declined to just 0.37% during 2002-2010 (Barazi-Yeroulanos, 2011). This was attributed to over-regulation and the lack of industrial policy in the European Union governance. A direct impact is that only 10% of the European fish consumption is satisfied by the European aquaculture production and the rest by imports (Larrazabal, 2012). At the same time, the R&D investments of the past decades lead to a transfusion of the developed innovated technologies on less developed countries – which are potential suppliers of the European markets with seafood products. Accordingly, special attention has to be paid towards a code of conduct for the national governments to promote the aquaculture activity by simplify the barriers and promote a friendly policy.

Finally, the need for a national plan for research and technology development for the mainstream and new cultured/farmed species, sustainable feed production, new farming technologies, new biotech products, processing, environmental issues and socio-economics has been proposed (Papandroulakis, 2014). Within this context, public administration is urged to assist the sector by using a collaboration consortium of the related Ministries (Agriculture and Rural Development, Environment, Marine, Development, and Education) to promote the activity and sustain its leading position worldwide.

## REFERENCES

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- Anonymous. 2004. Bridging genomes: an integrated genomic approach towards genetic improvement of aquacultured fish species-(BRIDGE-MAP). In European Conference on Marine Science & Ocean Technology, Galway, Ireland, 10-13 May 2004. pp. 181-182.
- AQUAMED. 2013. The future of research on aquaculture in the Mediterranean region. Developing a strategy for aquaculture research in the Mediterranean. FP7-KBBE-2009-3. [www.aquamedproject.net](http://www.aquamedproject.net)
- Asche, F., K.H. Roll, and R. Tveterås. 2007. Productivity Growth in the Supply Chain – Another Source of Competitiveness for Aquaculture. *Marine Resource Economics* 22:329–334.
- Asche, F., K.H. Roll, and R. Tveterås. 2012a. Innovations through the Supply Chain and Increased Production: The Case of Aquaculture. *IFIP Advances in Information and Communication Technology* 384:611-619.
- Asche, F., K.H. Roll, and R. Tveterås. 2012b. Innovations and Productivity Performance in Salmon Aquaculture. *IFIP Advances in Information and Communication Technology* 384: 620-628.
- Aspelund, A. 2013. What is Driving Innovation? Theory and Practice. In *Aquaculture Europe*, Trondheim, Norway.
- Barazi-Yeroulanos, L. 2010. Regional synthesis of the Mediterranean marine finfish aquaculture sector and development of a strategy for marketing and promotion of Mediterranean aquaculture (MedAquaMarket). *Studies and Reviews No. 88*. General Fisheries Commission for the Mediterranean. Rome: FAO. 195pp.
- Barazi-Yeroulanos, L. 2011. The importance of aquaculture for EU food production. In *EAS Aquaculture Europe 2011*. October 18-21, Rhodes, Greece.
- Barazi-Yeroulanos, L. 2013. Greek Marine Aquaculture Today. In *International Seminar: The future of Greek aquaculture: Building a sustainable industry in the framework of integrated coastal zone management/PEGASO Project*, Athens, Greece.
- Beza, P., J.A. Theodorou, D. Rizos, G. Papadopoulos, I. Zaridis, and I. Kagalou. 2008. Assessing the abiotic elements for the WFD implementation in the Mediterranean ecoregion: The case study of Maliakos Gulf (Greece). In *EAS Conference*, September 16-18, Krakow, Poland.
- Blancheton, J.P. 2013. The future of research on aquaculture in the Mediterranean region. The AQUAMED Project. 5th Annual Meeting of the EATiP, Brussels, Belgium.
- Chatziplis, D., C. Batargias, C.S. Tsigenopoulos, A. Magoulas, S. Kollias, G. Kotoulas, F.A.M. Volckaert, and C.S. Haley. 2007. Mapping quantitative trait loci in European sea bass (*Dicentrarchus labrax*): The BASSMAP pilot study. *Aquaculture* 272: (SUPPL. 1) S172-S182.

Christophiliogiannis, P., and J. Theodorou. 1995. Insurance Requirements of the Greek Mariculture Industry during the period 1986-1994 (1st semester). *Aquaculture Production Economics. Cahiers Options Mediterrannes*. 14: 239-246.

Commission of the European Communities. 2009. Building a sustainable future for aquaculture. A new impetus for the Strategy for the Sustainable Development of European Aquaculture. Impact Assessment. Commission staff working document accompanying the communication from the commission to the European Parliament and the Council. COM/2009/0162 final.

Danioux, C., X. Bompais, C. Loste, and P. Paquette. 2000. Offshore mollusc production in the Mediterranean basin. *Mediterranean offshore mariculture. CIHEAMIAMZ Cahiers Options Mediterrannes* 30:115–140.

Dimitriou, P.D., E.T. Apostolaki, N. Papageorgiou, S. Reizopoulou, N. Simboura, C. Arvanitidis, and I. Karakassis. 2012. Meta-analysis of a large data set with Water Framework Directive indicators and calibration of a Benthic Quality Index at the family level. *Ecological Indicators* 20:101-107

Dimitriou, P.D., I. Karakassis, P. Pitta, T.M. Tsagaraki, E.T. Apostolaki, I. Magiopoulos, N. Nikolioudakis, S. Diliberto, J.A. Theodorou, I. Tzovenis, I. Kagalou, P. Beza, and M. Tsapakis. 2015. Effects of mussel farming on quality indicators of the marine environment: Good benthic below poor pelagic ecological status. (submitted)

EATiP. 2012. European Aquaculture Technology and Innovation Platform. The future of European Aquaculture. Our vision: A strategic Agenda for research & Innovation. 42pp. [www.eatip.eu](http://www.eatip.eu).

Economou, V., C. Papadopoulou, M. Brett, A. Kansouzidou, K. Charalabopoulos, G. Filioussis and K. Seferiadis. 2007. Diarrheic shellfish poisoning due to toxic mussel consumption: the first recorded outbreak in Greece. *Food Additives Contaminants*. 24:297–305.

European Parliament. 2009. Directorate general for internal policies. Policy Department B: Structural and cohesion policies. Fisheries. European aquaculture competitiveness: Limitations and possible strategies. 128pp.

EU Regulation No 508/2014. 2014. Regulation of the European Parliament and the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council. *Official Journal of the European Union*. 20.5.2014, L 140/66.

FAO. 2006-2014. Fisheries and aquaculture software. FishStat Plus - Universal software for fishery statistical time series. In *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated November 28, 2013. <http://www.fao.org/fishery/statistics/software/fishstat/en>.

FEAP. 2013. Annual Report 2012.

FEAP. 2014. Annual Report 2014.

Frentzos, A. 2013. Greek mariculture: present and future. *Proceedings of the Hellenic Conference of Ichthyologists* 15:331-334.

- Harache, Y., and P. Paquotte. 1996. The development of marine fish farming in Europe: a parallel with salmon culture. Pages 388 In B. Chatain, M. Sargalia, J. Sweetman, and P. Lavens. *Sea bass and Sea bream Culture: Problems and Prospects. An International Workshop*. Verona, Italy: Special Publication of the European Aquaculture Society.
- Hough, C., G. Charalambakis, and J. Theodorou. 2000. Pan-European FEAP Data Base Project: The European Producers Networking. In: *Responsible Aquaculture in the New Millennium*, EAS Spec. Publ. No 28, p. 290.
- H Kathimerini, 2014. "Shots" to the public aquaculture companies by the small fish farmers. 9/7/2014. [www.Kathimerini.gr](http://www.Kathimerini.gr).
- Karakassis, I., P.D. Dimitriou, N. Papageorgiou, E.T. Apostolaki, N. Lampadariou, and K.D. Black. 2013. Methodological considerations on the coastal and transitional benthic indicators proposed for the Water Framework Directive. *Ecological Indicators* 29:26-33.
- Katsanevakis, S., N. Levin, M. Coll, S. Giakoumi, D. Shkedi, P. Mackelworth, R. Levy, A. Velegrakis, D. Koutsoubas, H. Caricm, E. Brokovich, B. Öztürk and S. Kark. 2015. Marine conservation challenges in an era of economic crisis and geopolitical instability: The case of the Mediterranean Sea. *Marine Policy* 51: 31–39.
- Kochras, D., L. Kokokiris, and S. Galinou-Mitsoudi. 2000. Lack of integrated coastal management in Thermaikos Gulf area. Working paper no. 9. COASTMAN Research Programme, Human Dimension of Environmental Change (ENV-CT97-0045).
- Konstantinou, Z. I., Y. N. Krestenitis, D. Latinopoulos, K. Pagou, S. Galinou-Mitsoudi, and Y. Savvidis. 2012. Aspects of mussel-farming activity in Chalastra, Thermaikos Gulf, Greece: an effort to untie a management Gordian knot. *Ecology and Society* 17(1):1.
- Koukaras, K. and G. Nikolaidis. 2004. Dinophysis blooms in Greek coastal waters (Thermaikos Gulf NW Aegean Sea). *Journal Plankton Research* 26:445–457.
- Kougias A. 2011. Demographics and dynamics of firms with R&D activities in Greece. MSc Thesis, Patras University, Greece. 162pp.
- Lane, A. 2013. Euroshell. How to bridge the gap between science and producers to support the European marine production sector? In 5th Annual Meeting of the EATiP, Brussels, Belgium.
- Larrazabal, G. 2012. Aquaculture in the reform of the Common Fisheries Policy. Level playing field for the profession. In EP Intergroup on Climate Change , Biodiversity and Sustainable Development Conference.
- Law No 4282/2014. 2014. "Aquaculture development and other directives". FEK A 182/29.8.2014.
- McKinsey and Company. 2012. Greece 10 Years Ahead. Defining Greece's new growth model and strategy. Executive summary. Athens Office, 70pp.
- Mendrinou, A., and J. Bostock. 2009. Study of the competition in Scottish salmon and Greek sea bass and sea bream industries. MSc Thesis, University of Stirling, UK.
- Moutopoulos, D.K. and C. Koutsikopoulos. 2014. Fishing strange data in national fisheries of Greece. *Marine Policy* 48: 114–12.

- Nash, C.E. 2011. The history of aquaculture. Wiley-Blackwell Publications. 244 pp.
- Papageorgiou, P.A. 1999. Marketing development for new Mediterranean aquaculture species: enterprise strategies. *Cahiers Options Mediterrannes* 47: 11-24.
- Papandroulakis, N. 2014. Greek Aquaculture. R & D priorities. A plan with vision to 2030. In Ministry Agricultural Development and Food Meeting "The developmental prospects of the European Aquaculture during the new programming period 2014-2020". *Fishing News (Greek)* 388:46-56.
- Papoutsoglou, S. E. 2000. Monitoring and regulation of marine aquaculture in Greece: licensing, regulatory control and monitoring guidelines and procedures. *Journal of Applied Ichthyology* 16:167–171.
- Pedini, M. 2000. Summary report of the TECAM seminar on Mediterranean marine aquaculture: Finfish species diversification. *Cahiers Options Medititerrannes* 47:381–386.
- Perdikaris, C., and I. Paschos. 2011. Aquaculture and fisheries crisis within the global crisis. *Interciencia* 36(1):76–80.
- Protopappas, D., and J.A Theodorou. 1995. The enrolment of the Greek mariculture industry. Federation of Greek Maricultures Publications.
- Rigos, G. 2013. The role of marine aquaculture research: needs, future trends and education. In International Seminar: The future of Greek aquaculture: Building a sustainable industry in the framework of integrated coastal zone management/PEGASO Project, Athens, Greece.
- Rodrigues, L.C., J.C.J.M. van den Bergh, F. Massa, J.A. Theodorou, P. Ziveri, and F. Gazeau. Sensitivity of Mediterranean Bivalve Mollusc Aquaculture to Climate Change and Ocean Acidification: Results from a producers' survey. (submitted).
- STECF (Scientific, Technical and Economic Committee for Fisheries). 2013. The Economic Performance Report on the EU Aquaculture sector (STECF-13-29). Publications Office of the European Union, Luxembourg, EUR XXXX EN, JRC XXX, 383 pp.
- Stephanis, J. 1995a. Farming of Mediterranean finfish species. Present status and potentials. In *The Greek Challenge*. Federation of Greek Maricultures Publications.
- Stephanis, J. 1995b. Economic viability of production systems seabass/ seabream in Greece (industrial scale). *Cahiers Options Mediterrannes* 14:65–77.
- Stephanis, J. 2000. Sea bass and sea bream success story: Which sustainable future? *Proceedings of AQUA 2000*. Nice, France.
- Stephanis, J. 2013. A case study: Mediterranean fish farming. Pages 22–23 in *Annual FEAP Report 2012*.
- The Economist. 2008. Grabbing it all. Special report: the sea. *The Economist*, Dec 30, 2008. <http://www.economist.com/node/12798494>.
- Theodorou, J. 1995. Pan-European Aquaculture Data Base Project by FEAP: The Greek Contribution. *Cahiers Options Mediterrannes*. 17:231–236.

Theodorou, J. 2001. Regulation and monitoring of shellfish aquaculture in Europe. Pages 55-57 in A. Read, T.F. Fernandes, K.L. Miller, A. Eleftheriou, M. Eleftheriou, I.M. Davies, and G.K. Rodger, ed. The implications of directives, conventions and codes of practice on the monitoring and regulation of marine aquaculture in Europe. Aberdeen, Scotland: Fisheries Research Services Publications.

Theodorou, J., and G. Charalambakis. 2001. Review on the fish farming development in Greece. Pages 49-54 in A. Read, T.F. Fernandes, K.L. Miller, A. Eleftheriou, M. Eleftheriou, I.M. Davies, and G.K. Rodger, ed. The implications of directives, conventions and codes of practice on the monitoring and regulation of marine aquaculture in Europe. Aberdeen, Scotland: Fisheries Research Services Publications.

Theodorou, J. 2002. Current & future technological trends of European sea bass-sea bream culture. *Reviews in Fisheries Science* 10(3-4):529-543.

Theodorou, J., M. Mastroperos, P. Pantouli and Y. Cladas. 2003. Insurance requirements of mariculture in Epirus. Proceedings of the 11th Hellenic Congress of Ichthyologists, Preveza, Greece.

Theodorou, J., and I. Tzovenis. 2004a. Aquaculture insurance. Pages 86-90 in J. Teugels, and B. Sundt, ed. *Encyclopedia of Actuarial Sciences*. John Wiley and Sons Publications.

Theodorou, J., and I. Tzovenis. 2004b. Aquaculture Insurance in Greece. 9th Aquaculture, Insurance & Risk Management Conference, Tavira, Portugal.

Theodorou, J. A., P. Sorgeloos, C. M. Adams, J. Viaene, and I. Tzovenis. 2010a. Optimal farm size for the production of the Mediterranean mussel (*Mytilus galloprovincialis*) in Greece. Proceedings of the 15th Biennial Conference of the International Institute of Fisheries Economics & Trade: Economics of Fish Resources and Aquatic Ecosystems: Balancing Uses, Balancing Costs.

Theodorou, J.A., J. Viaene, P. Sorgeloos, and I. Tzovenis. 2010b. Risk factors affecting the financial sustainability of the capture based aquaculture systems: the case of the Greek Mussel farming. Proceedings of the 5th AquaMedit International Congress on Aquaculture, Fisheries Technology and Environmental Management.

Theodorou, J.A., A. Kotsonis, P. Sorgeloos, J. Viaene and I. Tzovenis. 2010c. Risk assessment of seabass and seabream aquaculture based on insurance claims in Greece. Proceedings of the 15th Biennial Conference of the International Institute of Fisheries Economics & Trade: Economics of Fish Resources and Aquatic Ecosystems: Balancing Uses, Balancing Costs.

Theodorou, J. A., J. Viaene, P. Sorgeloos, and I. Tzovenis. 2011a. Production and marketing trends of the cultured Mediterranean mussel *Mytilus galloprovincialis* L. 1819, in Greece. *Journal Shellfish Research* 30(3):859-874.

Theodorou, J.A., R. James, I. Tzovenis, and C. Hellio. 2011b. Recruitment of the endangered bivalve *Pinna nobilis* L. (fan mussel) on *Mytilus galloprovincialis* L. long-line aquaculture ropes in the Maliakos Gulf, Greece. In: *Aquaculture Europe 2011- 'Mediterranean Aquaculture 2020'*, Organized by the European Aquaculture Society, October 18-21, Rhodes, Greece

Theodorou, J. A., I.C. Tzovenis, C.M. Adams, P. Sorgeloos, and J. Viaene. 2014a. Risk factors affecting the profitability of the Mediterranean mussel *Mytilus galloprovincialis* Lamarck 1819, farming in Greece. *Journal Shellfish Research* 33(3): 695–708.

Theodorou, J.A., I. Tzovenis, P. Sorgeloos, and J. Viaene. 2014b. From risk analysis to Greek crisis management in aquaculture: the case of the mediterranean mussel farming in Greece. In: 1st International Congress on Applied Ichthyology and Aquatic Environment –“HydroMedit 2014”, Volos, Greece, November 13-15.

Theodorou, J.A., R., James, D., Tagalis, I. Tzovenis, C. Hellio, and G. Katselis. 2015. Density and size structure of the endangered bivalve *Pinna nobilis*, Linnaeus 1758, (fan mussel) in the shallow water zone of Maliakos Gulf, Greece. submitted to *Italian Journal Zoology*.

Tsikliras, A.C., U.R. Sumaila, and K.I. Stergiou. 2013. Parallels in economic and ecosystem crises. *Ethics in Science and Environmental Politics* 13:23-25.

Zanou, B., and C. Anagnostou. 2001. Integrated management in the Drainage basin of the Thermaikos Gulf (NW-Aegean Sea): methodological steps and proposed measures, according to the win–win policy. *European Water Management* 4:33–42. Zanou, B., C. Anagnostou, and E. Papathanassiou. 2005. Seeking the factors to stimulate the users in the coastal zones planning. Case study: open discussions with mussel farmers in the Axios River (GR). *Mediterranean Marine Science* 6:107–115.

Zion, B., and A. Barki. 2012. Review-Ranching fish using acoustic conditioning: Has it reached a dead end? *Aquaculture* 344–349:3–11.

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## DISCLOSURE STATEMENT

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