AQUACULTURE AND FISHERIES CRISIS WITHIN THE GLOBAL CRISIS

Costas Perdikaris and Ioannis Paschos

SUMMARY

The present essay attempts to address the observed complex crisis of aquaculture and fisheries sectors within the broader context of global crisis, using examples of significant negative effects on natural and social environment. At the same time the underlying causes of the sectors' crisis are viewed under the lens of metabolic rift theory applied to shrimp farming, glass eel trade, and tuna fishing and farming for sushi. Current crisis in the Greek aquaculture sector is briefly reviewed as a representative example of aquaculture developmental process in western societies, followed by an attempt to address the emergence of organic aquaculture schemes. Finally, eco-sound directions and polices in aquaculture development are briefly discussed, in order to minimize environmental effects, social inequity and partially restore existing metabolic rifts.

Climate, Biodiversity and Environmental Crisis

Climate change is more than evident in many parts of the world, characterized by altered patterns of natural phenomena, severe damages and human casualties (IPCC, 2007). Moreover, ice melting and the resulting rise in sea level increasingly threat coastal lowlands due to flooding, erosion and salinization, and further alteration in the balance of aquatic systems (Handyside *et al*., 2007). Temperature rise will particularly affect freshwater fish (Cochrane *et al*., 2009) and the problem is expected to be severe, for example, for the 37% of the species in Greece that are already classified as threatened. In marine and brackish waters, tropical and subtropical alien species have extended their distribution pattern to the north of the Mediterranean (Zenetos *et al*., 2009). Overall, climate change is expected to favor many of the 11000 alien species recorded in Europe (EU, 2008).

North American non-indigenous crayfish species (NICS), which are asymptomatic carriers of the crayfish 'plague', were imported to Europe (via aquaculture, aquarium trade, as live food, and for re-stocking purposes) devastating in many countries the indigenous crayfish species (ICS) due to their aggressive behavior, higher growth rates and fecundity (Holdich *et al*., 2009). It was projected that European waters will be inhabited by NICS in 100 years time and few, critically endangered, ICS populations will be confined in limited isolated places (Taugbøl and Skurdal, 1999).

Although the 'polluter pays' principal has been welcomed by environmentalists, ecological footprint data revealed that the problem was particularly urgent in resource use. In Greece, the overall ecological footprint is about 3.5 times higher compared to the national available biocapacity, and about 2.2 times higher compared to the global ecological footprint (WWF,

KEYWORDS / Aquaculture / Fisheries / Global Crisis / Metabolic Rift / Organic Farming / Sustainable De-growth /

Received: 07/05/2010. Accepted: 12/01/2010.

Costas Perdikaris. Ichthyologist. Ph.D. in Astacology, University of the Aegean, Greece. Visiting Lecturer, Department of Aquaculture & Fisheries, Technological Educational Institute of Epirus (TEI), Greece. Address: Irinis & Filias 1, 46100 Igoumenitsa, Greece. e-mail: cperdik74@yahoo.gr

Ioannis Paschos. Ichthyologist. Ph.D. in Biology, Aristotle University of Thessaloniki, Greece. Professor, TEI, Greece.

CRISIS DE ACUICULTURA Y PESCA EN LA CRISIS GLOBAL
Costas Perdikaris e Ioannis Paschos

RESUMEN

En el presente ensayo se examina la compleja crisis del sector de acuicultura y pesca dentro de un contexto amplio de la crisis global, empleando ejemplos de efectos negativos significativos sobre el ambiente natural y social. Al mismo tiempo, las causas subyacentes a la crisis del sector son enfocadas bajo la perspectiva de la teoría de la brecha metabólica aplicada al cultivo de camarones, comercio de angulas, pesca de atún y cultivo para sushi. La crisis actual en la acuicultura griega es revisada brevemente, como ejemplo del proceso de desarrollo de la acuicultura en países occidentales, seguido de un intento por considerar la emergencia de esquemas de acuicultura orgánica. Finalmente, se discuten brevemente directrices y políticas ecológicamente aptas para el desarrollo de la acuicultura, a fin de minimizar los efectos sobre el ambiente y la inequidad social, y restaurar parcialmente la brecha metabólica.

CRISE NA AQUICULTURA E PESCA NA CRISE GLOBAL
Costas Perdikaris e Ioannis Paschos

RESUMO

No presente ensaio se examina a complexa crise do setor da aquicultura e pesca dentro de um contexto amplo da crise global, empregando exemplos de efeitos negativos significativos sobre o ambiente natural e social. Ao mesmo tempo, as causas subjacentes à crise do setor são focadas sob a perspectiva da teoria da brecha metabólica aplicada ao cultivo de camarões, comércio de meixão, pesca de atum e cultivo para sushi. A crise atual na aquicultura grega é revisada brevemente, como exemplo do processo de desenvolvimento da aquicultura em países ocidentais, seguido de uma tentativa por considerar a emergência de esquemas de aquicultura orgânica. Finalmente, se discutem brevemente diretrizes e políticas ecologicamente aptas para o desenvolvimento da aquicultura, a fin de minimizar os efeitos sobre o ambiente e a desigualdede social, e restaurar parcialmente a brecha metabólica.

2008). Footprint in aquaculture ranges from negligible to as much as 50000ha per ha activity, depending on species, farming methods and intensity (Beveridge *et al*., 1997; Folke *et al*., 1998). In fact, the ratio of wild fish inputs to farmed fish outputs in the intensively farmed carnivorous species (e.g. Atlantic salmon) is 5.0 compared to the average value of 0.63. Fish oil imports are dominated by Europe and volume requirements by the aquaculture sector is expected to determine the sectors role in the future of wild fisheries (Naylor *et al*., 2009).

Nutritional Crisis and Fiscal Growth: India on the Edge

Annual aquaculture growth in India follows the national economy trend (~7% during 2007-2009; EW, 2010; FAO, 2010). In the same time, 36% of the population lives below poverty line and 48% of the children of 0-5 years old are chronically malnourished (Arnold *et al*., 2009). Trade liberalization generated revenues to the national economy from shrimp exports, but at the same time it was responsible for an imbalanced growth and poverty increase at local level (Pradhan and Flahenly, 2008). In the agriculture sector, farming of genetically modified organisms (GMOs) by small farmers has compromised their livelihoods, since they cannot afford to pay for GMO grains, inorganic fertilizers, and pesticides. The overall picture implies that nutritional deficiencies and fiscal development can go hand to hand, especially when agricultural products became the new battleground for agro-fuel companies and stock exchange speculators.

Social Crisis

The collapses of Bear Sterns and Lehman Brothers opened the Pandora's Box for the globalized economic networks. Whether this is a decaying over-accumulation (capital concentration) crisis (Marx and Fowkes, 1992), followed by a reproduction crisis of the new high-tech era, or just a creative destruction phase of the previous economic cycle (Schumpeter, 1962), the current crisis has affected the real economy and society. Total unemployment rate reached 17.5% in the USA (Leonhardt, 2009) and 13.2% of the population (40 million people) live in poverty (DeNavas-Walt *et al*., 2009). This trend is expected to be accompanied by a parallel under-consumption crisis, and negatively affect consumption habits in fishery products. Currently, the predicted needs for fish food supplies are huge (i.e. 270.9×10^6 metric tons for 2050; Wijkström, 2003) and the aquaculture sector is expected to fill the demand gap. However, even if it is possible to overcome the finite character of natural resources, little evidence exists at present that *per capita* supply and consumption of fish products will rise, for example, in the sub-Saharan countries (~less than 8kg *vs* 16.5kg globally), suggesting that food security and accessibility opportunities even to basic goods are not related to the monetary gain-driven nature of the industrial aquaculture and fisheries sectors.

Fisheries in the Twilight Zone

Overexploitation of commercial fish stocks in most of the seas is mainly the result of industrial trawling (Watling and Norse, 1998). The collapse of Northeast Atlantic cod fishery and processing industry in New England during the 1990s (Hamilton *et al*., 2004a) was not a sudden event. Early signs of stress in Atlantic cod, halibut and other commercial stocks were evident from 1930s (Clausen and Clark, 2005). The evolution of fishery practices and technology resulted in mass production and decimation of large predators and, subsequently, to extracting fish of the lower trophic levels. It is now widely accepted that overfishing of predators leads to disruption of the energy flows between the food webs, increased by-catch and loss of biodiversity, and, finally, to collapse of the entire vulnerable ecosystems.

The ecological consequences of both 'fishing down the food chain' (Pauly *et al.*, 1998) and 'fishing down the deep' (Morato *et al.*, 2006) practices will have ultimately serious effects on populations which rely on fisheries. During the 1990s, overfishing and environmental stress in the North Sea caused depletion of commercial stocks and, accordingly, generated increased unemployment, business failures, and rapid structural demographic disturbances in the Faroe Islands (Hamilton *et al.*, 2004b). Currently, in developing countries that collectively represent 70% of total catch and 35% of small scale fisheries, 22-24 million fishermen and 68-70 million people who work in the postharvest sector are expected to face serious consequences from the fish supply crisis (Hall *et al.*, 2010). Political will at the international level currently reflects the dominance of fishery companies and trade laws over environmental laws, and the future of marine capture fisheries will be ultimately conditioned by political, social and economic factors, including aquaculture (Garcia and Grainger, 2005).

Metabolic Rifts in Industrial Fisheries and Aquaculture

Sustainable development principles have become the mainstream doctrine. However, the dominant neoliberal attitude and practice towards the environment (i.e. continued economic expansion in order to built capital for investment) has produced irreversible environmental disasters.

Material exchange in biological chemistry and agriculture, where depletion of soil nutrients was observed early (mid 18th century), led Carl Marx to deploy the concept of metabolic rift. Capitalism is the driving force for centuries and organizes social metabolism with nature on the base of capital, production and profit escalation. However, the equilibrium of these dynamic metabolic processes between humans and nature are frequently ruptured, as constant inputs of finite resources are required and wastes are accumulated. Such a rupture (metabolic rift) also threatens the stability and biological integrity of aquatic ecosystems (Clausen and Clark, 2005). Accordingly, industrial aquaculture ('Blue Revolution') is challenged as a 'quick-fix' to transcend ecological limits and existing metabolic rifts such as

a) The development of shrimp farming by the construction of mega-farms both in Central America and Asia. In India, Bangladesh, Thailand and many Southeastern Asia countries, for example, shrimp farms were built on unfit acidic soils after clearing mangrove forests (Barbier and Sathirathai, 2004). Moreover, post larvae production is entirely based on wild broodstock (Primavera, 2006). The use of open farming systems resulted in continuous degrading water quality (Naylor *et al.*, 1998). Finally, the shrimp sector in most countries has been devastated by the infection by White Spot Syndrome Virus (Flegel and Alday-Sanz, 2007), with serious soioeconomic impacts to local communities and economies.

b) The unprecedented exploitation of glass eel stocks in European waters was evident during the last 15 years, in order to fulfill the demand by Chinese farms; it resulted in sky-high prices glass eels (>€1000/kg) and dramatic decrease of natural stocks in European inland waters (ICES, 2008). Accordingly, eel was registered in the IUCN list of threatened species.

c) The exploitation of mature stocks of Mediterranean bluefin tuna, which have almost crashed and most specimens caught are far below the reproductive age (MacKenzie *et al.*, 2009). Tuna farming for sushi depends solely on state quotas in Europe, as well as on fish caught in the Mediterranean waters of North Africa. Recently (on March 2010), the involved parties (EU, USA, Japan, Canada, etc.) failed to halt tuna fishing during the last CITES meeting, by-passing the urgent alerts of most fishery scientists who suggested zero quotas (Black, 2010), while favoring the fishing industry and their lobbies.

Aquaculture Sector: The Greek Case

Cotemporary aquaculture in Greece is ~25 years old, even though freshwater production practically started with the introduction of rainbow trout during the Marshal Aid Program (1948-1952; Perdikaris *et al.*, 2010). Mariculture development was based on the availability of suitable sites, French, Italian and Japanese knowhow, and financial support from EU structural programs. However, after 1995, a few large corporations were formed via aggressive merging and direct purchasing of smaller farms, backed by bank loans and 'cheap' money from the Athens stock exchange. The process was further accelerated by artificial price recession, suffocating small and medium scale producers. The result was that from about 300 farm owners in the late 1980s-early 1990s, only 16 companies or group of companies control about 70-75% of total production (particularly, 3 companies control 90% of juvenile production and 60% of fish feed production) (Barazi-Yeroulanos, 2010). Today, the sector is irreversibly loan and substitute dependent (capital intensive), and also fish oil and fish meal dependent. The economic crisis was used as the perfect alibi to increase profit return from capital, by minimizing labor cost (reducing the salaries of all workers or significantly sacking programs). In this situation, farming companies, fish feed companies, banks and peripheral suppliers will be seriously affected by a possible spiral deleveraging phase.

Organic Aquaculture: Sound Practice or Marketing Trick?

Organic movements such as IFOAM aim to bring together farmers and associations engaged in organic agriculture, livestock farming and aquaculture (IFOAM, 2007). However, the organic ('ecological friendly') nature of the process has been strongly debated and sometimes is characterized as 'oxymoron' on the base of resource use, spread of parasites and genetic 'polution' of natural stocks (Staniford, 2001).

In Asia, organic production has been practiced for centuries without the need of sophisticated technology, chemicals, inorganic fertilizers, increased stocking densities and mechanized processes (Beveridge and Little, 2007). It started as a means of providing supplementary income to rural families by maintaining the excess fish caught in backyard ponds fed with agricultural, household by-products, wastewater and sewage. However, based on the available production data, Europe is the leading player in organic aquaculture. Contemporary organic schemes would be valuable if 1) used in species close to the trophic chain (e.g. tilapias, various cyprinids; Perdikaris and Paschos, 2010); 2) resource inputs are kept to a minimum, compared to product and waste outputs; and 3) applied to extensive and semi-intensive small and medium scale systems, harmonically integrated to the surrounding landscape. Additionally, integrated livestock/fish, agricultural crops/fish, rice/shrimp or prawns and fish/shellfish farming schemes could be useful (FAO/ICLARM/IIRR, 2001). On the other hand, organic approaches in intensive systems using carnivore species are currently conceived as a way to bypass overproduction, profit margin and marketing bottlenecks, and therefore require ethical justification on the grounds of resource exploitation and use.

The Way Ahead

The current complex global crisis is directly related to climate and physical environment, biodiversity, economy, and social welfare. Industrial scale aquaculture and fisheries function within this context, but at the same time they possess their own crisis intricacies, which can be fairly understood by the application of metabolic rift theory. Fisheries are no longer available to satisfy the demand gap, and aquaculture already supplies 50% of total fish and mollusks consumed. Although feeding conversion ratios and feeding management have been improved in piscivorous fish, fish meal and fish oil requirements doubled over the last decade (Tacon and Metian, 2008), enhancing the existing metabolic rift. Efforts currently concentrated on fish meal and fish oil replacement (Turchini *et al*., 2009) create additional metabolic rifts on the land.

The application of radical sustainable de-growth economic principles (Georgescu-Roegen, 1971) in multinational large scale fishing fleets and mega-farm structures would be justified especially in proven detrimental activities, in order to protect natural resources, reduce social inequity, and partially restore certain metabolic rifts. It can be seen as an active and society-driven remediation process and a sound tool, to reverse the ecological consequences of the ongoing aggressive capitalist production. On the other hand, the supply crisis and the observed nutritional crisis in many places of the developing world could be mitigated by the wider application of bottom production farming strategies involving low value herbivore species. In parallel, equity policies, better management practices, and self regulation in small and medium size farms (Subasinghe *et al*., 2009) should be strongly promoted.

Organic production in aquaculture is steadily increasing (Tacon and Brister, 2002) and could assist in reducing the ecological footprint of the sector. Developing countries would be largely benefited from certified organic production, either due to close resemblance to traditional practices, or due to the ideal temperature conditions and availability of water resources (e.g. in sub-Saharan countries especially for Nile tilapia and African catfish; Anguilar-Manjarrez and Nath, 1998). Low impact aquaculture (Bunting, 2006) requires the application of ecological footprint approaches and carrying capacity tools. Moreover, effective controls in resource and space utilization would reduce social tensions and resolve present conflicts with other activities.

The development of cooperatives by small and medium producers and artisanal fishermen at the production and processing levels should be strengthened within a context of community-based management. Such an organization has been proved valuable in assisting poverty alleviation and also in meeting protein needs. Application of horizontally integrated aquaculture (FAO/ICLARM/IIRR, 2001) could sustain employment opportunities in rural and coastal fishing communities, combined with participatory planning, extension services and public education.

Finally, national legislation frameworks should shift towards trade bans of invasive alien species and NICS, and the application of strict risk assessment methods (De Silva *et al*., 2009) on the rest of them. Moreover, no-go areas, ark sites and sanctuaries (Holdich *et al*., 2009) could be valuable tools to protect threatened species and ecosystems, supported further by rehabilitation and restocking programs involving scientists, local communities and schools.

REFERENCES

Aguilar-Manjarrez J, Nath SS (1998) *A Strategic Reassessment of Fish Farming Potential in Africa*. CIFA Technical Paper Nº 32. Food and Agriculture Organization. Rome, Italy. 170 pp.

Arnold F, Parasuraman S, Arokiasamy P, Kothari M (2009) *Nutrition in India. National Family Health Survey (NFHS-3), India, 2005-2006*. International Institute for Population Sciences. Mumbai, India / ICF Macro. Calverton, Maryland. 59 pp.

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 General Fisheries Commission for the Mediterranean N° 88. Food and Agriculture Organization. Rome, Italy. 195 pp.

Barbier EB, Sathirathai S (2004) *Shrimp farming and mangrove loss in Thailand*. Edward Elgar Publishing. Cheltenham, UK. 268 pp.

Beveridge M CM, Little DC (2007) The history of aquaculture in traditional societies. In Costa-Pierce BA (Ed.) *Ecological aquaculture: The evolution of the blue revolution*. Blackwell Science Ltd, Oxford, UK. pp. 3-29.

Beveridge MCM, Phillips MJ, Macintosh DC (1997) Aquaculture and the environment: the supply and demand for environmental goods and services by Asian aquaculture and the implications for sustainability. *Aquacult. Res. 28*: 797-807.

Black R (2010) *Bluefin Tuna Ban Proposal Meets Rejection*. BBC Channel. http://news.bbc.co.uk/2/hi/science/nature/8574775.stm (Cons. 06/20/2010).

Bunting SW (2006) *Low Impact Aquaculture*. Centre for Environmental and Society Occasional Paper 2006-3. University of Essex, UK. 32 pp.

Clausen R, Clark B (2005) The Metabolic rift and marine ecology. An analysis of the ocean crisis within capitalist production. *Org. Env. 18*: 422-444.

Cochrane K, De Young C, Soto D, Bahri T (Eds.) (2009). *Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge*. FAO Fisheries and Aquaculture Technical Paper. Nº 530. Food and Agriculture Organization. Rome, Italy. 212 pp.

DeNavas-Walt C, Proctor BD, Smith JC (2009) *Income, Poverty, and Health Insurance Coverage in the United States: 2008*. U.S. Current Population Reports. P60-236. Census Bureau. Government Printing Office. Washington DC, USA. 72 pp.

De Silva SS, Nguyen TTT, Turchini GM, Amarasinghe US, Abery NW (2009) Alien species in aquaculture and biodiversity: a paradox in food production. *Ambio 38*: 24-28.

EU (2008) *Towards an EU Strategy on Invasive Species* (COM/2008) 789. European Commission. http://ec.europa.eu/environment/nature/invasivealien/index_en.htm (Cons. 20/06/2010).

EW (2010) *India and the Global Economy*. EconomyWatch www.economywatch.com/indianeconomy/india-and-global-economy.html (Cons. 06/20/2010).

FAO (2010) *Fishery and Aquaculture Country Profiles. India*. Food and Agriculture Organization. Rome, Italy. www.fao.org/fishery/countrysector/FI-CP_IN/en (Cons. 06/20/2010).

FAO/ICLARM/IIRR (2001) *Integrated Agriculture-Aquaculture: A Primer*. FAO Fisheries Technical Paper Nº 407. Food and Agriculture Organization. Rome, Italy. 149 pp.

Flegel TW, Alday-Sanz V (2007) The crisis in Asian shrimp aquaculture: current status and future needs. *J. Appl. Ichthyol. 14*: 269-273.

Folke C, Kautsky N, Berg H, Jansson A, Troell M (1998) The ecological footprint concept for sustainable seafood production: A review. *Ecol. Appl. 8*: S63-S71.

García SM, Grainger RJR (2005) Gloom and doom? The future of marine capture fisheries. *Philos. Trans. R. Soc. Lond. B Biol. Sci. 360*: 21-46.

Georgescu-Roegen N (1971) *The Entropy Law and the Economic Process*. Harvard University Press. Cambridge, MA, USA. 472 pp.

Hall SJ, Dugan P, Alisson EH, Andrew NL (2010) The end of the line: Who is most at risk from the crisis in global fishries? *Ambio 39*: 78-80.

Hamilton LC, Haedrich RL, Duncan CM (2004a) Above and below the water: Social/Ecological transformation in Northwest Newfoundland. *Popul. Env. 25*: 195-215.

Hamilton LC, Colocousis CR, Johansen STF (2004b) Migration from resource depletion: The case of the Faroe Islands. *Soc. Nat. Resour. 17*: 443-453.

Handisyde NT, Ross LG, Badjeck MC, Alisson EH (2007) *The Effects of Climate Change on World Aquaculture: A Global Perspective*. Department for International Development. London, UK. www.aqua.stir.ac.uk/GISAP/pdfs/Climate_full.pdf (Cons. 06/20/2010).

Holdich DM, Reynolds JD, Souty-Grosset C, Sibley PJ (2009) A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. *Knowl. Manag. Aquat. Ecosyst. 394-395*: 1-46.

ICES (2008). *Report of the Joint EIFAC / ICES Working Group on Eels (WGEEL)*, 3-9 September 2008. ICES CM 2008 / ACOM: 15. International Council for the Exploration of the Sea. Leuven, Belgium.

IFOAM (2007) *Basic Standards for Organic Production and Processing*. International Federation of Organic Agriculture Movements www.ifoam.org/about_ifoam/standards/norms/norm_documents_library/IBS_V3_20070817.pdf (Cons. 06/20/2010).

IPCC (2007) *Climate Change 2007: Synthesis Report*. Contribution of working groups I, II and III to the 4th assessment report of the IPCC (Pachauri RK, Reisinger A, Eds.). Intergovernmental Panel on Climate Change. Geneva, Switzerland. 104 pp.

Leonhard D (2009) *Broader measure of U.S. unemployment stands at 17.5%*. The New York Times. www.nytimes.com/2009/11/07/business/economy/07econ.html?_r=1 (Cons. 06/20/2010).

MacKenzie BR, Mosegaard H, Rosenberg AA (2009) Impending collapse of bluefin tuna in the northeast Atlantic and Mediterranean. *Conserv. Let. 2*: 26-35.

Marx K, Fowkes B (Transl.) (1992) *Capital: Volume 1: A Critique of Political Economy*. Penguin Classics. 1152 pp.

Morato T, Watson R, Pitcher TJ, Pauly D (2006) Fishing down the deep. *Fish Fisher. 7*: 24-34.

Naylor RL, Goldburg RJ, Mooney H, Beveridge M, Clay J, Folke C, Kautsky N, Lubchenco J, Primavera J, Williams M (1998) Nature's subsidies to shrimp and salmon farming. *Science 282*: 883-884.

Naylor R L, Hardy RW, Bureau DP, Chiu A, Elliott M, Farrell AP, Forster I, Gatlin DM, Goldburg RJ, Hua K, Nichols PD (2009) Feeding aquaculture in an era of finite resources. *Proc. Natl. Acad. Sci. USA 106*: 15103-15110.

Pauly D, Christensen V, Dalsgaard J, Froese R, Torres FJr (1998) Fishing down marine food webs. *Science 279*: 860-863.

Perdikaris C, Paschos I (2010) Organic aquaculture in Greece: a brief review. *Rev. Aquacult. 2*: 102-105.

Perdikaris C, Gouva E, Paschos I (2010) Alien fish and crayfish species in the Hellenic freshwaters and aquaculture. *Rev. Aquacult. 2*: 110-120.

Pradhan D, Flahenly M (2008) National initiatives, local effects: Trade liberalization, shrimp aquaculture and coastal communities in Orissa, India. *Soc. Nat. Resour. 21*: 63-76.

Primavera JH (2006) Overcoming the impacts of aquaculture on the coastal zone. *Ocean Coast. Manage. 49*: 531-545.

Schumpeter JA (1962) *Capitalism, Socialism, and Democracy*. 3rd ed. Harper & Row. New York, USA. 61 pp.

Staniford D (2001) Organically farmed salmon is an oxymoron. *Org. Stand. 3*: 14.

Subasinghe R, Soto D, Jia J (2009) Global aquaculture and its role in sustainable development. *Rev. Aquacult. 1*: 2-9.

Tacon AGJ, Brister DJ (2002) Organic aquaculture: current status and future prospects. In El-Hage Scialabba N, Hattam C (Eds.) *Organic Agriculture, Environment and Food Security*. Environment and Natural Resources Series Nº 4. Food and Agriculture Organization. Rome, Italy. pp. 163-176.

Tacon AGJ, Metian M (2008) Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds. *Aquaculture 285*: 146-158.

Taugbøl T, Skurdal J (1999) The future of crayfish in Europe: How to make the best of a bad situation? In Gherardi F, Holdich DM (Eds.) *Crayfish in Europe as alien species - how to make the best of a bad situation?* A.A. Balkema. Rotterdam, Netherlands. pp. 271-279.

Turchini GM, Torstensen BE, Ng W-K (2009) Fish oil replacement in finfish nutrition. *Rev. Aquacult. 1*: 10-57.

Watling L, Norse EA (1998) Disturbance of the seabed by mobile fishing gear: a comparison with forest clear-cutting. *Cons. Biol. 12(6)*: 1180.

Wijkström UN (2003) Short and long-term prospects for consumption of fish. *Vet. Res. Commun. 27*(Suppl. 1): 461-468.

WWF (2008). *Living Planet Report*. World Wide Fund for Nature. Gland, Switzerland. http://assets.panda.org/downloads/living_planet_report_2008.pdf (Cons. 06/20/2010).

Zenetos A, Pancucci-Papadopoulou M-A, Zogaris S, Papastergiadou E, Vardakas L, Aligizaki K (2009) Aquatic alien species in Greece (2009): tracking sources, patterns and effects on the ecosystem. *J. Biol. Res.-Thessalon. 12*: 135-172.