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## Main Lecture

# Aquaculture in Sicily: the state of the art

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**ABSTRACT -** Aquaculture in Sicily, represented almost exclusively by seabass and sea bream production, together with capture fishery, plays a significant role in the regional economy. On a national basis, the regional production covers about 20% of Italian euryhaline fish production. Fingerling supply is guaranteed by the two hatcheries present on the Island. Twelve floating cage farms and two inshore farms annually produce about 4,000 t of fish. A small extensive production arises from the storage basins of the salt work of Trapani. This niche production could represent an opportunity to realize a new distinctive organic aquaculture, preferred by the consumers respect to intensive produced fish, that could contribute to promote the Territory. Two bluefin tuna fattening farms produce about 1,300 t of *sashimi grade* tuna annually. The aquaculture sector in Sicily faces the same problems of the Italian and Mediterranean sectors. However, Sicily is considered a Convergence Region by the European Union Cohesion Policy and is legible for special funding. The operational program 2007/2013 "European Fishery Found" will be an effective instrument to stimulate investment and technological innovation and to promote sustainable development of fisheries and aquaculture in the Region.

*Key words*: Aquaculture, Sicily, Fish-waste, Precautionary principle, Ecosystem approach.

As recently reviewed by Roncarati and Melotti (2007) in Italy, a modern and efficient Mediterranean euryhaline finfish aquaculture developed in the mid '80s of the last century, when problems arising, mainly, from the lack of swimbladder inflaction, were solved (Moretti *et al*., 1999; 2005). In the late '90s Italian hatcheries were able to produce up to 120 millions fingerlings (Roncarati and Melotti, 2007). At present, the Italian production of Mediterranean euryhaline fish occupies a significant position in the European Union aquaculture (IREPA, 2008), with a total production of about 20,000 t, mainly represented by seabass and seabream (MIPAF, 2007). However, the Italian aquaculture sector is facing the same difficulties of the entire EU aquaculture sector. In a more optimistic scenario (Bostock *et* al., 2008) EU aquaculture will grow at a rate required to meet the gap between declining capture fisheries and market seafood demand. In this scenario, among the different aquaculture technologies, seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*) production will undergo a growing rate of about 22% in the next ten years (Bostock *et al*., 2008). EU policy is directed toward the development of aquaculture, with a target of an annual production growth of 3.4–4.0%, focusing on new markets outlet, species diversification and environmental friendly production (Sturrock *et al*., 2008). This new EU policy was a conse-

quence of the price crisis of 2002 determined by the imbalance between supply and demand caused (DMIA, 2004; Bostock *et al*., 2008; Sturrock *et al*., 2008). In the early '90s of the last century, Mediterranean finfish aquaculture experienced the first price crisis, when the ex-farm prices fell from 13.0 to 15.0 €/kg to about 6.0 €/kg. During the second crisis, over the period of January 2001 to March 2002, prices for seabass and seabream fell from 5.75 and 5.0 €/kg to around 3.75 and 2.75 €/kg, respectively, probably due to overproduction, prices appeared to have fallen below cost of production (DMIA, 2004).

Aquaculture in Sicily, in addition to the common European difficulties, suffers from the stagnation of the regional economy and for the general difficulties in starting a stable and durable economic development (MIPAF, 2007). In consideration of the fact that Sicilian Gross Domestic Product (GDP) per inhabitant is less than 75% of the average value of the EU, Sicily, as other Italian and European Regions, is considered eligible by EU for funding under the Convergence objective. This economic support will involve also the Fishery and aquaculture sector.

In the context of the regional economy, on a whole, fishery and aquaculture represent 0.58% of total Sicilian Economy, compared to a value of 0.17% of the other Italian Convergence Regions (Basilicata, Calabria, Campania, and Puglia) and compared to a value of 0.08% for the Italian Regions not considered under the Convergence Objective of the EU (MIPAF, 2007).

Aquaculture in Sicily has an annual yield of about 4,000 t, representing around the 20% of total Italian production (IREPA; 2008; MIPAF, 2007). It is almost exclusively based on seabass and seabream production, with an average ratio of 54 to 46%. Small and variable quantity of other marine species are produced (ARTA, 2008; Modica *et al*., 2008), such as: sharpsnout seabream (*Diplodus puntazzo*), red porgy (*Sparus pagrus*) common dentex (*Dentex dentex*), amberjack (*Seriola dumerili*), meagre (*Argyrosomus regius*), Mediterranean bluefin tuna (*Thunnus thynnus*). Commercial shellfish culture is limited to small mussel farms in the Provinces of Palermo, Messina and Syracuse (Prioli, 2008; ARTA, 2008); however, the most part of them seems to be purification centres for bivalve molluscs. The Regional Pilot Centre for Aquaculture of *Assessorato Agricoltura e Foreste* of the Sicilian Region coordinates research, development and pilot scale production in fresh water aquaculture. This production (ARTA, 2008; Milano, 2008) is represented by small quantities of Sicilian autochthons trout (*Salmo cettii*) (Schöffmann *et al*., 2007), rainbow trout (*Oncorhynchus mykiss*), euryhaline species (*Morone* spp.) in sea cages and crayfish (*Cherax* spp.). This sector is expected to grow rapidly in the next few years, in consideration of the high number of fresh water reserves present in the Region (http://laghivivi.it/).

Sicilian aquaculture started at the end of the '70s in Marsala (Trapani), where the hatchery technologies for seabass and seabream production were introduced (Bertolino *et al*., 1979; Mazzola *et al*., 1980). This localization was not fortuitous. In the area, in fact, there is a very old tradition in fish rearing.

Along the coast between Trapani and Marsala (Western Sicily) 1400ha of salt pans are located. These environments, generated by human work, are characterized by significant peculiarities from ecological, cultural and etno-anthropological points of view. For these reasons salt works of Trapani and Marsala are protected by two Regional Natural Reserves. In addition to salt production, in the first storage basins of the saltworks, where the salinity reaches maximum values of 60‰, self recruited seabass and seabream are reared in extensive (Santulli, 2007; Santulli and Messina, 2008). The yield of the 350 ha of storage basins is very low (from 50 to 90q) but it has a very high economic value (18-22 €/kg) (Santulli,

2007). **Furthermore, it is worth stressing the high value that this activity can assume for** the Territory. For the salt works of Trapani, the produced sea salt (*the white gold of Sicily*) was chosen as the *"flag natural product"* to promote the Protected Area. The niche production of organic cultured fish from salt work basins, due to high consumer interest in natural products, could be implemented or applied as additional "flag product" to promote the Territory. Fish farming in the salt work basins could represent an opportunity to realize a new distinctive organic aquaculture production, characterized by culture system that does not utilize artificial diet and does not exert negative environmental impact, but generates a natural fish product, preferred by consumers (Santulli, 2007; **Santulli and Messina, 2008).**

Following the pioneering preliminary phase, in the '80s and the '90s three inshore farms, provided with hatcheries, were active in the area. After the price crisis, all these aquaculture plants were closed and the inshore aquaculture in the Province of Trapani almost completely disappeared.

Table 1. Inshore aquaculture farms in Sicily in 2008.

| Province | Municipality | Surface ha | Species |
|---|---|---|---|
| Trapani | Marsala | 65 | seabass, seabream, sharpsnout seabream and shellfish |
| Siracusa | Pachino | 10 | seabass, seabream, meagre, sharpsnout seabream |

At the present, a fish farm, realized in the basins of an abandoned salt work is active near the Stagnone Lagoon (Marsala). This farm that represents one of the two inshore fish farms present in Sicily (Table 1), produces in semi-intensive and in intensive seabass, seabream and other fish species, that are commercialized directly in the farm or in the local catering market.

In the Province of Syracuse there is another inland fish farm (Table 1). This plant belongs to the biggest Sicilian fish farm, that is also provided with a hatchery and with floating cages.

The two inshore Sicilian fish farms have an annual production of 600/650 t.

Table 2. Aquaculture farms in floating cages in Sicily in 2008.

| Province | Municipality | Surface $m^2$ | Species | Cage number |
|---|---|---|---|---|
| Agrigento | Lampedusa | 7,225 | seabass, seabream | 4 |
| | Licata | 11,206 | seabass, seabream | 9 |
| | Licata | 21,000 | seabass, seabream, sharpsnout seabream, red porgy | 17 |
| Siracusa | Pachino | 24,918 | seabass, seabream, meagre, sharpsnout seabream, | 12 |
| | Augusta | 250,000 | seabass, seabream | 10 |
| Messina | Messina | 12,000 | seabass, seabream | 6 |
| | Gioiosa Marea | 20,000 | seabass, seabream | 6 |
| | Lipari | 3,000 | seabass, seabream, sharpsnout | 7 |
| | Venetico | 10,000 | seabass, seabream, sharpsnout | 6 |
| | Patti | 20,000 | seabass, seabream, sharpsnout | 10 |
| | Villafranca Tirr. | 150,000 | seabass, seabream, sharpsnout | 8 |
| Palermo | Trappeto | 1,500,000 | seabass, seabream, sharpsnout seabream, red porgy | 14 |

After the crisis of the inland farm in the Province of Trapani, the axis of aquaculture in Sicily moved offshore and towards the Western part of the Island (Table 2).

In the 2008 (Table 2), twelve aquaculture farms were active in Sicily (ARTA, 2008; Modica *et al*., 2008), using different typologies of floating cages. Some farms, localized in a sheltered area, utilise the more simple floating cage system, represented by net pens suspended from plastic floating collars; other farms, localized in more exposed zones, are provided with semi submersible and submersible flexible cages, ore the more complex and expensive submersible rigid cages, such as Farmocean (Modica *et al*., 2008).

In the regional scenario, two main classes of farms can be recognized (Modica *et al*., 2008): the first one represented by medium-large farms, consolidated from economical and technological point of view, with a high and stable production of high quality fish; the other one includes small farms, characterized by reduced investments, small production and, generally, economic difficulties.

This situation could explain the large variability in farm number that characterized the regional aquaculture sector (Modica *et al*., 2008).

Supermarket chains are either already or are fast becoming, the dominant force for aquaculture production also in Sicily (Modica *et al*., 2008). This market being accessible only to the biggest farm that can satisfy the pressing request in terms of constancy of size, quality and availability of the produced fish. The Sicilian producers are starting to negotiate and trade with organizations much larger than their own, also through producer cooperation.

In other European markets, multiple retailer chains increasingly dominate the retail market and the market of traditional fishmongers decreases (DMIA, 2003). In Sicily, most part of the production of the smallest farms is destined to the local market by traditional channels (specialist retailers, fishmongers and wholesalers) that use the expressed preference of consumers for locally grown products over imports that, usually, are unbranded.

The catering market is of particular importance in Sicily. However the increasing demand seems to be met by fish of small size locally produce or by relatively cheap imported fish. Imports are commonly unbranded and quality is reported to be highly variable due to long transit times and post-harvest handling. This last undesirable event encourages the efforts of some Sicilian fish farms to improve the image of local products, enhanced through quality assurance schemes. Sicilian Farmers, being aware that in a context of intense competition branding the product can be a winning strategy (Monfort, 2006), are committed to make Regional farmed fish easily identifiable, by individual fish tagging indicating the place of origin and the farming brand.

The regional demand for juvenile seabass and seabream is satisfied by the two hatcheries present (Table 3). These two hatcheries are also able to export more than 10,000,000 fingerlings per year. The two Sicilian hatcheries are also involved in research programs to develop the reproduction technology for autochthonous new species. The amberjack represents one of the main objectives, due to its particular favourable biological and commercial characteristics.

Table 3. Hatcheries of euryhaline fish in Sicily in 2008.

| Province | Municipality | Fry number |
|---|---|---|
| Siracusa | Pachino | 16/18,000,000 |
| Agrigento | Lampedusa | 7/9,000,000 |

As it has already happened for euryhaline finfish aquaculture at the end

of the '70s, the Province of Trapani was also the incubator of other new aquaculture technology. In 2001, in fact, the first floating cage farm devoted to the fattening of Bluefin tuna in Italy started its activity in the Gulf of Castellammare, Trapani (Table 4), followed by the farm of San Pier Niceto, Messina two years later.

Table 4. Tuna fattening farms in Sicily in 2008.

| Province | Municipality | Surface $m^2$ | Cage number | Situation |
|---|---|---|---|---|
| Trapani | Castellammare del Golfo | 122,500 | 6 | Active |
| Messina | San Pier Niceto | 480,000 | 10 | Active |

Bluefin tuna fattening is a particular aquaculture technology that undergoes in the Mediterranean in a very rapid development (Messina, 2009), following the high request of the rich Japanese market, which requires high quality tuna, with a high fat content, for *sushi* and *sashimi* (Messina, 2009). *Sashimi grade* tuna only constitutes 30% of the overall quantity of caught fish and, therefore, the fattening period in the cages satisfies the requirements of the Japanese market, even in the period when the wild tuna fish are leaner, assuring a stable and consistent production in more favourable periods (Messina, 2009).

This technology, however, cannot be consider "farming", since the fish are not bred and reared in captivity (Ottolenghi *et* al., 2004; Ottolenghi, 2008; Messina, 2009).

Adult tuna, preferentially bigger than 70 kg, in fact, are caught by purse seine in June/July; when after reproduction, the flesh quality does not meet the Japanese demand. Caught tuna are transferred by towing cages, at a speed of 1-1.5 knots, to the farm and fed on defrosted bait fish, of species characterized by high lipid content (Aguado and García, 2003; Ottolenghi *et al*., 2004; Ottolenghi, 2008; Messina, 2009). After 5/7 months, when farmed tuna reach the high quality request, in terms of flesh colour and lipid content (Messina, 2009), they are killed rapidly, by confinement and gunshot to the head, to reduce slaughtering stress and the subsequent quality of flesh deterioration (Messina and Santulli, 2007; Messina, 2009). Killed tuna are rapidly filleted and fillets are frozen by nitrogen and exported to Japan (Messina, 2009).

The medium to long term survival of Mediterranean bluefin tuna fattening is very difficult to forecast, due to the serious problem encountered by this precious overexploited resource. Recently, the first encouraging results in artificial reproduction of bluefin tuna (Ugolini, 2008), can justify the scenario foreseen by the EU: assuming that hatchery/nursery technology will be developed in the next ten years, will show a projection growth rate up to 75% (Bostock *et al*., 2008).

Sicily, as already reported, from the point of view of EU Cohesion Policy, is classified as a Convergence Region and is legible for special funding. The operational program 2007/2013, that defines the strategy of EU for the sector of fishery and aquaculture is the Italian "European Fishery Found" (EFF), approved with the Commission decision of December 12th 2007, that assigns 636,563,728 € to support for the sustainable development of fisheries and aquaculture in the Italian Convergence Regions. In particular, *Priority axis 2: Aquaculture, inland fishing, processing and marketing of fishery and aquaculture products* of the EFF has the purpose to support productive investments in aquaculture and investments in processing and marketing of fishery and aquaculture products, with a priority for micro and small enterprises, with a budget of 159,140,932 €.

On the basis of our experience, among the numerous single and collective actions that will be proposed in Regional EFF to contribute to the development of the aquaculture sector in Sicily, two aspects are worth considering: the first one dealing with added-value product, the second one concerns the interaction of aquaculture with marine environment and the image that consumers perceive.

One of the possible actions indicated by *Priority axis 2* of the EFF concerns the market research to determine consumer requirements, followed by action to promote existing products and the development of new ones, such as added-value fish-food products. A variety of product forms falls within this category. Filleted, gutted, boneless, headed fish, etc. could contribute to find new markets, to increase consumer acceptability and, then, to improve the Mediterranean aquaculture economic value (Lanari *et al*., 1999; DMIA, 2003; Monfort, 2006).

To complete the productive chain, large amounts of waste that this new industry generates could be an important source of many bioactive high value compounds (Van der Wielen and Cabatingan, 1999). In this regard, using marine resources, according to Van der Wielen and Cabatingan (1999), it has to be considered that: "*…..there is a need to develop more sustainable processes relative to those in the early days of Moby Dick*". Therefore, the development of industrial processes to extract bioactive compounds still present in processing wastes of seabass and seabream could have a significant role in raising the sustainability and the economic condition of the Sicilian aquaculture market (Messina *et al*., 2009).

Among the wide range of bioactive compounds present in fish species not utilized for human feeding and in wastes originated by fish processing industry, polyunsaturated fatty acids (PUFA) are particularly interesting (Shahidi and Wanasundara, 1998).

Aquaculture utilizes more than 50% of 0.8/1.2 million tons of fish oil world production. An analysis of production and consumption trends indicate that in 2015 the global fish oil demand will exceed supply, reaching almost 145% (FAO, 2002).

Individuation of alternative fonts of lipids and proteins is determinant to reduce the pressure of aquaculture on natural fishery resources. Overexploitation of feed fish, utilized to prepare fish oil determines, in fact, many concerns for the effect on marine fishery resources (Naylor *et al*., 2000). These observations stimulate the research of PUFA natural sources alternative to fish, such as exploitation of new aquatic organisms, development of new technologies and utilization of fish transformation industry by-products (Messina *et al.*, 2009).

However, it could be more interesting, from the economic point of view, the value that fish oil can assume after PUFA ω3 fraction enrichment (Messina, 2009).

The bluefin tuna fattening industry, for example, produces a large amount of waste that has to be incinerated, representing a cost for the farmers. In our recent results, concerning the utilization of waste from the bluefin tuna fattening industry, we increased the concentration of PUFA ω3 of crude oil extracted by tuna wastes, from 19.61±0.65% up to 54.99±1.32%, by $C0_2$ supercritical fluid separation (Messina, 2009). Concentrated tuna oil can have a nutraceutical and pharmaceutical utilization, with a dramatic increase of their economical value (Messina, 2009) and, consequently, farmed tuna wastes, instead of being a cost, could represent a further remunerative income for the farm.

Collective actions proposed by the *Priority axis 3: Measures of common interest* of the EFF could represent the right instrument for a Sicilian aquaculture Producer Organisation by implementing their production through a pilot plan to define the possibility of utilization of waste produced by transformation of aquaculture production.

Within the last couple of decades there has been an increasing interest from the consumers for the protection of the environment and the consumption of environmentally friendly products. Consumers want to know whether the production of an item causes damage to the environment and require some sort of labelling guarantee that the product is in compliance with environmental (and social) requirements. This has determined an increase of the demand for eco-labelled products (Modica *et al*., 2008).

The need to respond to requests of the consumers has led to increasing interest in certification of aquaculture production systems, practices, processes and products according to ISO 14001 and EMAS normative (Modica *et al*., 2008). The aquaculture sector driven by consumer concerns initiated to ensure its sustainability and to protect operations from poorly managed activities. In many cases, an effective approach to voluntary regulation is the adoption of codes of practices that contain best management practices (BMPs), with the aim to minimize adverse environmental impacts, customized for site characteristics, production and local interests (Modica *et al*., 2008).

Also in Sicily the aquaculture sector has made significant advances in this field (Modica *et al*., 2008). There are some examples of improved management that have reduced environmental impacts and improved efficiency by the application of BMPs (Santulli, 2009). However the main difficulty encountered by the aquaculture in Sicily, as all over the world, is represented by the lack of confidence, arising from the concerns on the effects of the environment of this relatively new food production sector.

Aquaculture is still considered a human activity with strong adverse effects on the environment. However, as recently reviewed (Santulli, 2009), if the farm is localized in a suitable site and if BMPs are adopted by the farmers, the local effects of aquaculture are limited in space and in time. This consideration is according to the recent literature (Santulli, 2009 for a review) and is based on the results of an eight year monitoring of the environmental effects of the Mediterranean bluefin tuna fattening farm of Castellammare del Golfo (Santulli, 2009). The project that has started from the first rearing campaign in 2001 at present has the purpose to strengthen and increase knowledge related to the rearing of this species, in order to develop a responsible and sustainable production through the optimization of rearing techniques, the increase of sustainability and control of production cycle.

The growth of world aquaculture has led to a multiplicity of concerns attached to environmental impacts, social impacts, food safety, animal health and welfare and economic/financial issues. The precautionary principle is generally invoked to support requests for much stricter control and, in some instances, *moratoria* on further development, leading in some cases to overregulation of the aquaculture activity, while other sectors with a longer history of production have negative impacts that have traditionally been accepted (Hambrey and Southall, 2002; Bartley *et al*., 2007).

Recently, as requested from the Regional EFF, the Guide Lines for building fish farms in Sicily were published (ARTA, 2008). The Guide Lines individuate the sites suitable for implantation of fish farms along the Regional coasts and define the methodology for *ex-ante* evaluation of the site and for the monitoring of local impacts of the farm, requesting a long list of expensive and time consuming environmental analyses.

These Guide Lines are, as stated (ARTA, 2008), inspired by a precautionary principle. This policy, instead of promoting sustainable development of aquaculture stimulating investment and technological innovation, risks to encumber the budget of the Sicilian aquacul-

ture. In addition, it does not contribute to the efforts of farmers to build an environmental friendly image of the aquaculture in Sicily to meet the consumer's demand.

"Ecosystem Approach to Aquaculture" (EAA) could be the right strategy to contribute to aquaculture development in Sicily. EAA aims to sustain the use of aquatic environments by treating aquaculture as a part of the entire ecological and socio-economic systems, rather than as a distinct unit, considering Humans and their activities specific components of the ecosystem (Brugère *et al*., 2007).

**REFERENCES - Aguado,** F., García García, B., 2003. Macronutrient composition of food for bluefin tuna (*Thunnus thynnus thynnus*) fattening. In: Proceedings of the 1st International Symposium on DOTT, Bridges C.R., Gordin H., García A. (Eds.). Cahiers Options Médit. 60:15-16. **ARTA,** Assessorato regionale del territorio e dell'ambiente, 2008. Linee guida per la realizzazione di impianti di maricoltura in Sicilia". Gazzetta Ufficiale della Regione Siciliana 6(suppl. ord.), 37 pp. **Bartley,** D.M., Brugère, C., Soto, D., Gerber, P., Harvey, B., 2007. Comparative assessment of the environmental costs of aquaculture and other food production sectors: methods for meaningful comparisons. FAO/WFT Expert Workshop. 24-28 April 2006, Vancouver, Canada. FAO Fisheries Proceedings. No. 10. Rome, FAO. 245 pp. **Bertolino,** A., Mazzola, A., Rallo, B., 1979. Esperienza sulla crescita larvale della spigola (*Dicentrarchus labrax* L. 1758) in cattività. Ed. Arti Grafiche Corrao, Trapani, 3-22. **Bostock,** J., Muir, J., Young, J., Newton, R., Paffarath, S., 2008. Prospective analysis of the aquaculture sector in the Eu. Part 1: synthesis report. Papatryfou I. (Ed.), JRC EU, IPTS, Luxemburg, 152 pp. **Brugère,** C., Soto, D., Bartley, D.M., 2007. Comparative environmental costs of aquaculture and other food production sectors: environmental and economic factors conditioning the global development of responsible aquaculture. In: "*Comparative assessment of the environmental costs of aquaculture and other food production sectors: methods for meaningful comparisons*". Bartley, D.M., Brugère, C., Soto, D., Gerber, P., Harvey, B. (Eds.). FAO/WFT Expert Workshop. 24-28 April 2006, Vancouver, Canada. FAO Fisheries Proceedings. No. 10. Rome, FAO, pp. 25-35. **DMIA,** Department of Marketing & Institute of Aquaculture, University of Stirling, 2004. Study of the market for aquaculture produced seabass and seabream species. Report to the European Commission DG Fisheries, EC tender FISH/2004/05, 84 pp. **FAO,** 2002. Use of fishmeal and fish oil in aquafeeds: further thoughts on the fishmeal trap, by M.B. New & U.N. Wijkström. FAO Fisheries Circular No. 975. Rome. 61 pp. **Hambrey,** J., Southall, T., 2002. Environmental risk assessment and communication in coastal aquaculture. FAO, Roma, pp. 1-69. **IREPA**, 2008. Osservatorio economico sulle strutture produttive della pesca marittima in Italia. Milano Franco Angeli ed., pp 198. **Lanari,** D., Poli, B.M., Ballestrazzi, R., Lupi, P., D'Agaro, E., Mecatti, M., 1999. The effect of dietary fat and NFE levels on growing European sea bass (*Dicentrarchus labrax* L.). Growth rate, body and fillet composition, carcass traits and nutrient retention efficiency. Aquaculture 179:351-364. **Mazzola,** A., Rallo, B., 1980. Esperienze sull'allevamento di avannotti di orata (*Sparus aurata* L.) riprodotti artificialmente. Mem. Biol. Mar. Oceanogr. 10:415-416. **Messina,** C., 2009. Allevamento e qualità del prodotto. In: "*La stabulazione del tonno rosso mediterraneo (Thunnus thynnus) in Provincia di Trapani*", Santulli, A., Messina, C. (Eds.). Arti Grafiche Corrao, Trapani, 96 pp. **Messina,** C., Santulli, A., 2007. Effect of slaughtering methods on stress and quality of caged bluefin tuna (*Thunnus thynnus*). In: IFOAM Conference on organic aquaculture, Cattolica Italy, 18/20 June 2008. pp. 29-31.

**Messina,** C., La Barbera, L., Arena, R., Mistretta, G., Santulli, A., 2009. By-products from wild and reared *Dicentrarchus labrax* as a potential source of polyunsaturated fatty acid**.** Food Res. Int., submitted. **Milano,** A., 2008. Gambero yabby e trota macrostigma: le nuove strategie dell'acquacoltura. Terra e Vita 17:60-61. **MIPAF,** Ministero delle Politiche Agricole Alimentari e Forestali, 2007. Programma Operativo FEP per il settore pesca. CCI: 2007IT-14FPO001. 178 pp. **Modica,** A., Santulli, A., Scilipoti, D., 2008. Acquacoltura. In: *"Relazione sullo Stato dell'Ambiente in Sicilia 2007"*. Regione Siciliana, Assessorato Regionale del Territorio e dell'Ambiente. Palermo, pp. 69-89. **Monfort,** M.C., 2006 Markets and Marketing of Aquaculture Finfish in Europe Focus on the Mediterranean Basin For FAO Fisheries division. www.marketing-seafood.com 84 pp. **Moretti,** A., Pedini Fernandez-Criado, M.; Cittolin, G., Guidastri, R., 1999. Manual on hatchery production of seabass and gilthead seabream. Volume 1.Rome, FAO. 194 pp. **Moretti,** A., Pedini Fernandez-Criado M., Vetillart, R., 2005. Manual on hatchery production of seabass and gilthead seabream. Volume 2. Rome, FAO. 152 pp. **Naylor,** R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H., Troell, M., 2000. Effect of aquaculture on world fish supplies (review article). Nature 405:1017–1024. **Ottolenghi,** F., 2008. Capture-based aquaculture of bluefin tuna. In: *"Capture-based aquaculture. Global overview"*. Lovatelli A. e Holthus P.F. (Eds.). F.A.O. Fisheries Technical paper No. 508, FAO, Rome, pp 169-182. **Ottolenghi,** F., Silvestri, C., Giordano, P., Lovatelli, A., New, M.B., 2004. Capture-based aquaculture: the fattening of eels, groupers, tunas and yellowtails. FAO, Rome, pp. 308. **Prioli,** G., 2008. La molluschicoltura in Italia. In: "*Estado actual del cultivo y manejo de moluscos bivalvos y su proyección futura: factores que afectan su sustentabilidad en América Latina*". Lovatelli, A., Farías, A., Uriarte, I., (eds). FAO Actas de Pesca y Acuicultura. No. 12. Roma, FAO. pp. 159–176. **Roncarati,** A., Melotti, P., 2007. State of the art of Italian aquaculture. Ital. J. Anim. Sci. 6(suppl. 1):783-787. **Santulli,** A., 2007. Acquacoltura in salina: promozione protezione e valorizzazione: definizione ed applicazione di una metodologia a impatto ridotto per l'allevamento semi intensivo in saline ricadenti all'interno di riserva naturale. Consorzio Universitario della Provincia di Trapani, pp. 326. POR Sicilia 2000/06, N°1999. IT.16.1.PO.011/4.17B/8.3.7./0063. **Santulli,** A., 2009. Interazioni con l'ambiente marino. In: *"La stabulazione del tonno rosso mediterraneo (*Thunnus thynnus*) in Provincia di Trapani"*, Santulli, A., Messina, C., (Eds.). Arti Grafiche Corrao, Trapani, 120 pp. **Santulli,** A., Messina, C., 2008. Quality of fish reared in extensive in the salt works of Trapani and Marsala (Western Sicily). Sea salt and fish as flag products to promote territory and Natural Reserves. In: IFOAM Conference on organic aquaculture, Cattolica Italy, 18/20 June 2008, pp. 29-31. **Schöffmann,** J., Sušnik, S. Snoj, A., 2007. Phylogenetic origin of *Salmo trutta* L 1758 from Sicily, based on mitochondrial and nuclear DNA analyses. Hydrobiologia, 575:51–55. **Shahidi,** F., Wanasundara, U.N., 1998. Omega-3 fatty acid concentrates: nutritional aspects and production technologies. Trends Food Sci. Technol. 9:230-240. **Sturrock,** H., Newton, R., Paffarath, S., Bostock, J., Muir, J., Young, J., Immink, A., Dickins, M., 2008. Prospective analysis of the aquaculture sector in the EU. Part 2: characterization of emerging aquaculture systems. Papatryfou I. (Ed.), JRC EU, IPTS, Luxemburg, 188 pp. **Ugolini,** R., 2008. Progetto Allotuna a Vibo Marina: la riproduzione del tonno. In: *"Il tonno rosso nel Mediterraneo. Biologia, pesca, allevamento e gestione"*. Ottolenghi, F., Cerasi, S. (Eds.). Unimar, Roma, pp. 74-74. **Van der Wielen**, L.M., Cabatingan, L.K., 1999. Fishing products from the sea-rational downstream processing of marine by-products. J. Biotechnol. 70:363-371.