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RESEARCH ARTICLE

Preliminary approach of bioremediation through the booster of adult ripe stock of the sand smelt in the Lesina lagoon

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Abstract

1 - *Atherina boyeri* (Risso, 1810) is a small, eurhyaline atherinid fish common widespread in Lesina lagoon, nevertheless water eutrophication and over-fishing directly and indirectly affect this species.

2 - This study aims to propose the better strategies to increase the reproductive stocks of sand smelt in order to carry out a bioremediation process recovering its key trophic role in the Lesina lagoon.

3 - The sand smelt stocks in the lagoon, according to the recent scientific findings, could be considered a triggering tool to manage the excessive nutrient load in transition environments, which is at the base of aquatic trophic web, as well as to fight the mismanagement of fishing due to fishermen abuse.

Keywords: Lesina Lagoon; Adriatic Sea; Bioremediation; Adult Ripe Stock; Booster

Introduction

Atherina boyeri (Risso, 1810) is a small, eurhyaline atherinid fish that mainly inhabits coastal and estuarine waters, including coastal lagoons, over a wide range of salinities, from freshwater to hyper saline conditions (Andreu-Soler *et al.*, 2003).

It is common in the Mediterranean and boundary seas as well as Lesina lagoons where it's one of main commercial resources of local fisheries (Leonardos and Sinis, 2000). The macro-zoo benthos organisms are the natural food of *Atherina boyeri*: this alimentary habits give to sand smelt an important ecological role for this lagoon, specially considering that it is one of few species that spend in the lagoon its entire life span. In Lesina lagoon its spawning season is observed from February to June, nevertheless ripe adults are observed in October too (Vaglio *et al.*, 1998).

The over-fishing practiced in the last century and the contemporaneous eutrophication processes caused a trophic web outbreak in the lagoon ecosystem, with direct and indirect effects on environmental and economic area. The main aim of this study, funded by Apulia Region, is to increase the reproductive stocks of sand smelt, decreased as a consequence of excessive fishing, in order to carry out a bioremediation process recovering the key trophic role of this small fish.

Materials and methods

Starting from June 2006 adult sand smelt were weekly captured for biometric purposes in the Lesina lagoon (Fig. 1), by using a fyke-net tool taking a random sub-sample of 30 specimens at time. At the start of the experiment some tens of them were carefully transferred to the laboratory, avoiding excessive transport shock. The laboratory facilities (Fig. 2) were accurately kept distinct from the outdoor conditions; the lighting was artificial with timing planning of photoperiod independent of

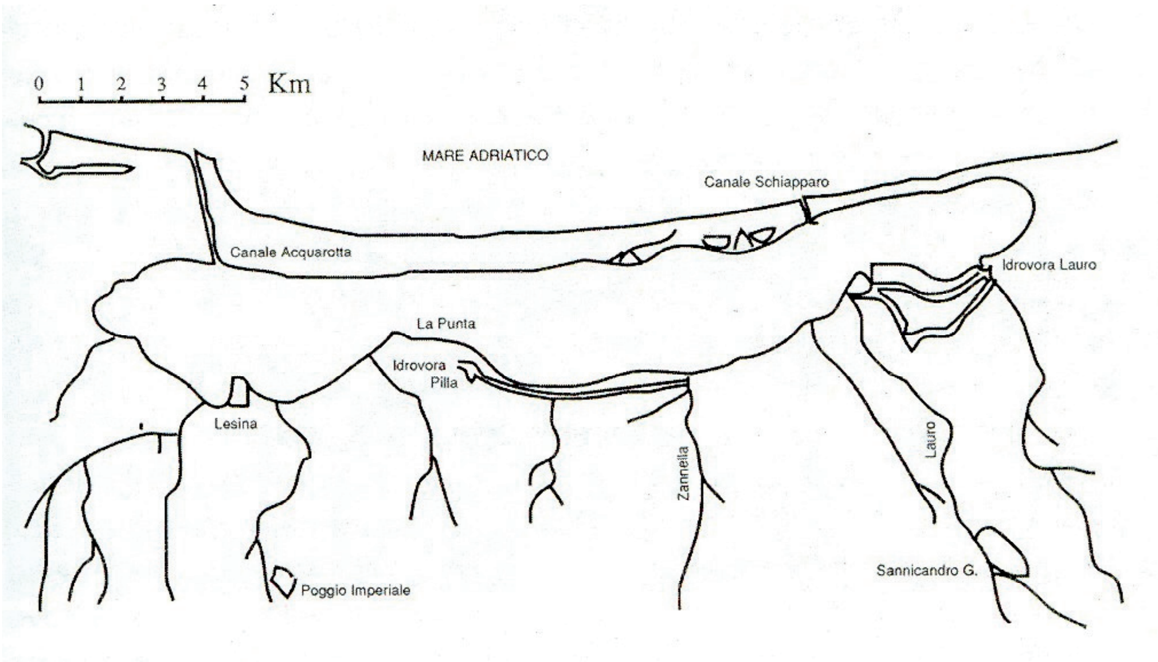

Figure 1. Site study: the Lesina lagoon (Apulia, Italy).

sunshine and sunset. After a short quarantine and feeding on *Artemia* nauplii, the fishes were stocked in a 500 liter set of aquaria, supplied with lagoon water, completely re-circulated through a sand filter and a phytodepuration step. The last employs macro algal biomass of *Chaetomorpha linum* Kuntz. In short time after the initial live preys feeding, the sand smelts were switched on commercial pelleted food (*Perla Plus 3.0 – Skretting*). The livestock was kept to follow the sexual maturation phase, by the conditioning of the physical-chemical parameters (temperature, salinity, and photoperiod). The photoperiod was set up through two procedures: the first tied to natural run of the sun cycle mediate by twilight; the other regulated by a timer with arbitrary dark/light (D/L) sequences. The 500 L aquaria was kept at 20 ± 1 °C, the water salinity ranged between 20 and 25

Figure 2. Indoor set of aquaria with re-circulating water and phytodepuration step.

psu, the photoperiod was 10/14 D/L during the breading and 14/10 D/L during the maturation conditioning. The sub-samples were used for gonad biopsy, standard length and weight measurement.

Concurrent experiment in a land based set of 80 m^2 ponds, was set up to follow in outdoor scale the maturation of sand smelts kept in captivity, which were fed commercial food (*Perla Plus 4.0 – Skretting*) at the rate of 1% of fish biomass. The pond received about 5 kg of fresh weight fish just caught, at the beginning of January 2008. The ponds were equipped with two airlift pump system to achieve water circulation and oxygen supply, as well as with macro algal bed of *Gracilaria ex verrucosa* for phytodepuration purposes. In that way, it was not necessary to renew the lagoon water in the pond, except for the seepage quantities. Water sampling for physico-chemical and nutrient analyses were routinely run according to standardized laboratory procedures.

Results

Laboratory livestock

Reproductive stock was completed in April 2007 (Table 1) and initially the artificial lamp photoperiod to which it was exposed, synchronized to the sun shining.

In August 2007 the first eggs were released. In January 2008 the photoperiod was set at 14/10 D/L calculated on the average of the natural phase of the sun during the previous months of July-August, and after 30 days of conditioning, the reproductive stock, kept in the laboratory, started to lay viable eggs, which were incubated for further larval rearing (Fig. 3). The eggs need a solid support on which attach themselves (in our case they attached on *Chaetomorpha linum* Kuntz filaments, Fig. 4). Beginning from June 2008 the stock was kept in the breading phase (10/14 D/L) to suspend the breeding. The maturation conditioning was restarted in August 2008 and the viable eggs released in October. Larvae culture feeding was based on rotifers for few days, then *Artemia* nauplii for a week and artificial pellets (*Perla Plus1.0*) after the fortnight on. In the prevailing conditions rearing, the larvae reached 3 cm average length (FL) in 3 months (Fig. 5). The biopsy for the few specimens risen in this cycle, revealed advanced gonad formation for the female (3th stage according to Holden and Raitt, 1974 modified).

Table 1 - Laboratory live stock. Set of aquaria lighted with artificial lamps in thermostatic room.

April 2007	Sun synchronized	Stock constitution
up to August 2007	Sun synchronized	First few viable eggs release
from January 2008	Not sun synchronized (14/10 D/L)	
up to February 2008	Not sun synchronized (14/10 D/L)	Quantitative viable eggs release; start of larval rearing
from June 2008	Not sun synchronized (10/14 D/L)	Stock on breading phase
from August 2008	Not sun synchronized (14/10 D/L)	Stock on maturation phase
to October 2008	Not sun synchronized (14/10 D/L)	Stock on maturation phase; Eggs release

Figure 3. Sand smelt larva reared in the laboratory.

Figure 4. Sand smelt eggs attached to *Chaetomorpha linum* Kuntz.

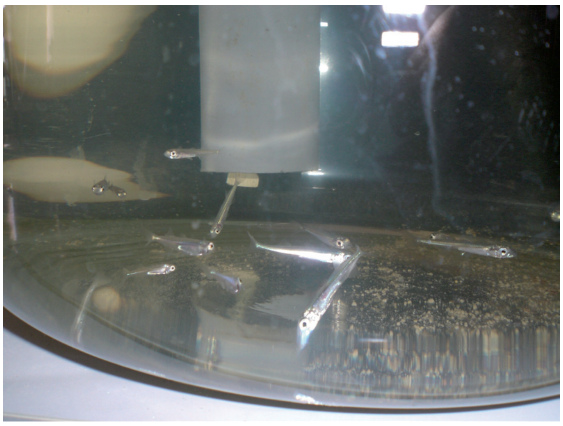

Figure 5. Sand smelt larva reared in the laboratory after three months.

Land base pond

In the outdoor experiment the livestock was fed directly on artificial pellets (*Perla Plus 4.0 – Skretting*) at the rate of 1% (dry weight), but it could not exclude that supplementary feeding came from the epibionts of the algae bed. The nutrient load coming from the catabolism of the fish stock never became troublesome. Dissolved oxygen (DO) and redox potential (ORP) were kept in optimal range, even during the warm months (April and May) presumably due to the algae bed effect (Fig. 6). Ripe adults were achieved after three months rearing (Table 2), coinciding with the natural maturation time of wild specimen sampled concurrently (Fig. 7). The first eggs laid, attached to the *Gracilaria* branches, and were considered the warning signal to act the fish stock release in the lagoon.

Discussion

Atherina boyeri constitutes a strategic ring of the first level food chain in transition environment, since it preys opportunistically on small aquatic organisms found in the pabulum, its life span is short and it lives in large shoal. On reverse, transition environment as a general rule should be preserved from anthropic hazard (Maci and Basset, 2009). Recently, studies have classified more than few species of the genus Atherina, which share the feeding habits (Trabelsia *et al.*, 1994; 2002; 2004; Milana *et al.*, 2008), contributing to exploit the food chain of macro-zoobenthos and zooplankton, otherwise left ineffective in eutrophic lagoons. The over-fishing practised by Lesina fishermen have caused several impairing of the aquatic food chain, namely excess of the mesofauna, that constitutes the prevailing component of the decaying matter in the waters. The Lesina lagoon suffers, among others, of the increase of organic matter accumulation on the bottom, which means reduced export of edible fishing species. The

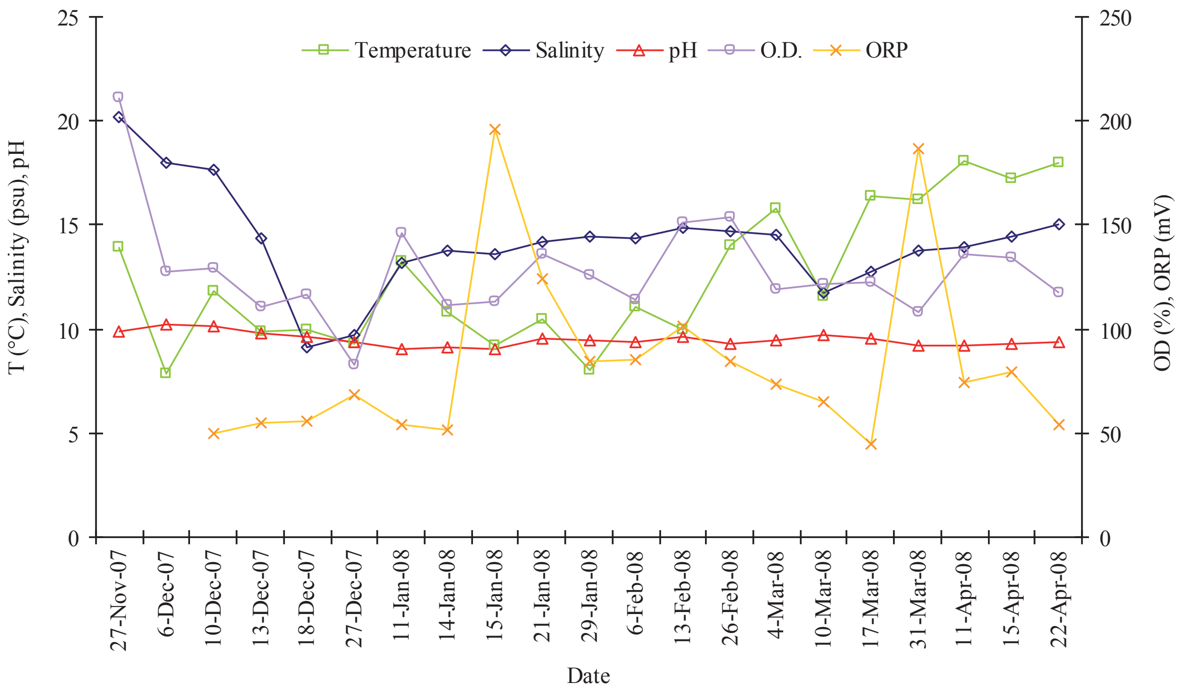

Figure 6. Trend of physico-chemical parameters in the outdoor experiment (land based pond with *Atherina boyeri* and a macroalgal bed of *Gracilaria ex verrucosa*).

average production of fish caught is about 40 kg ha-1 *per* year, really poor compared to lagoons well managed. In order to counteract the over-fishing, here it is suggested to restore the reproductive stock of sand smelt by bioremediation, i.e. practising on large scale the conditioning to the maturation of this fish in protected areas of the lagoon, and the release of ripe specimen in the wild. The intend to increase the reproductive stock of *Atherina* into lagoon is possible

Table 2 - Outdoor live stock in 80 m2 surface

Time	Observations
January 2008	Stock constitution; 5 kg *per* pond fresh weight
May 2008	Ripe population
June 2008	Release of ripe stock into the lagoon

to attain by restrictive measure of fishing rule or alternatively by creating nursery area forbidden to the fishing. Lesina lagoon fulfils most of the conditions requested to host a confined nursery area because of the rich vegetable assemblage made both by hydrophytes and seaweed (Trotta, 1994). The restoration of this food chain could contribute to reduce the excess of preys commonly hunted by the sand smelt, and make this fish stock efficient food pabulum for higher scale predator like sea bass and eel (Moretti *et al.*, 1958; Bartulovich *et al.*, 2004). This last author reported a special increase of sea bass fishing in the river mouth of Mala Neretva concomitant with recent massive population settlement in the area by sand smelt. Parallel report is coming from local fishermen of Lesina lagoon, who experienced periodically an increase of sea bass fishing and a meaningful reduction of sand smelt fish stock, and conversely poor catch of big predator concomitant to sand smelt abundance. Most of the authors studying *Atherina boyeri* (Leonardos and Sinis, 2000; Koutrakis, 2004; Patimar *et al*., 2009) report almost always a male/female ratio less than 1, that is found in Lesina too (Fig. 7) caused by various factors (environmental, genetic, etc.). Males had a lower life span than females; the latter dominating length classes most of the time (Koutrakis, 2004). Raising *Atherina boyeri* in controlled conditions it seems that the precocity of female body growth, compared to the male one, could help to explain the change of the ratio found during the fishing season in the Lesina lagoon, specially using of fixed net during the fishing season (October-February). This fishing procedure is based on the trapping of each specimen in the net mesh by the head. The mesh size is stated by the fishing rule, almost always violated by the fishermen who prefer undersized mesh, so that the final effect is a selective reduction of females (Fig. 8) from the reproductive stock. The sand smelt stocks, according to the recent scientific findings, could be considered a triggering tool to manage the excessive nutrient load in transition environments, which is at the base of aquatic trophic web, as well as to fight the mismanagement of fishing due to fishermen abuse. In order to try this approach, at the end of the outdoor experiment all the sand smelt adult stocks were released in the wild. Finally to achieve quantitative results in the long run, all the outdoor experiments should be replicate on larger scale.

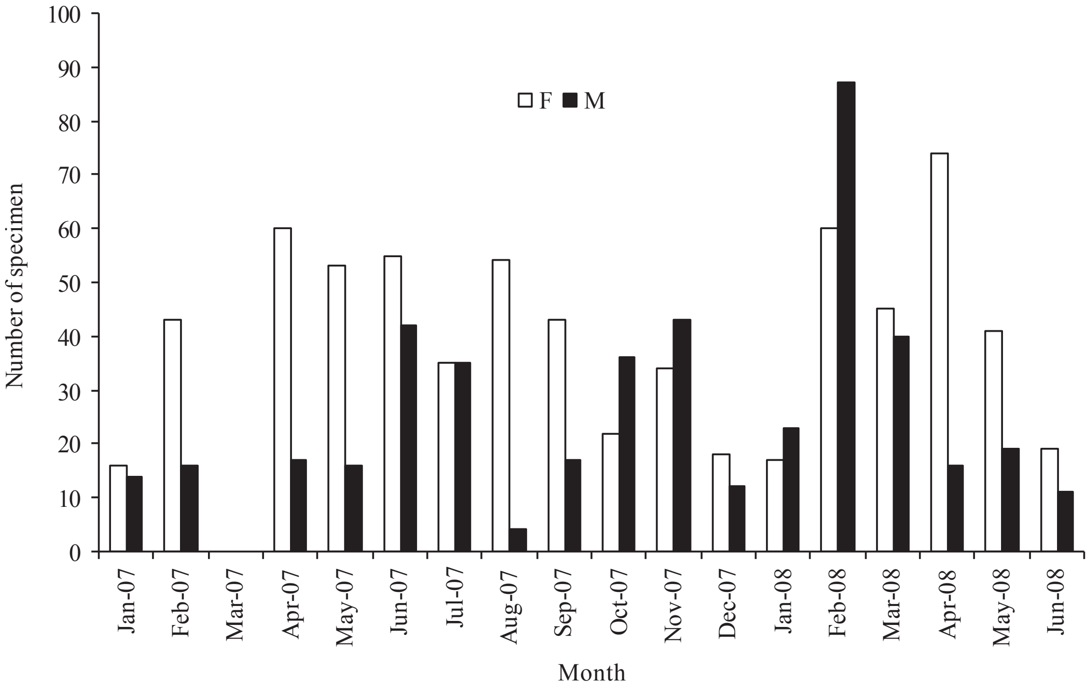

Figure 7. Male/Female ratio of *Atherina boyeri* in the Lesina lagoon.

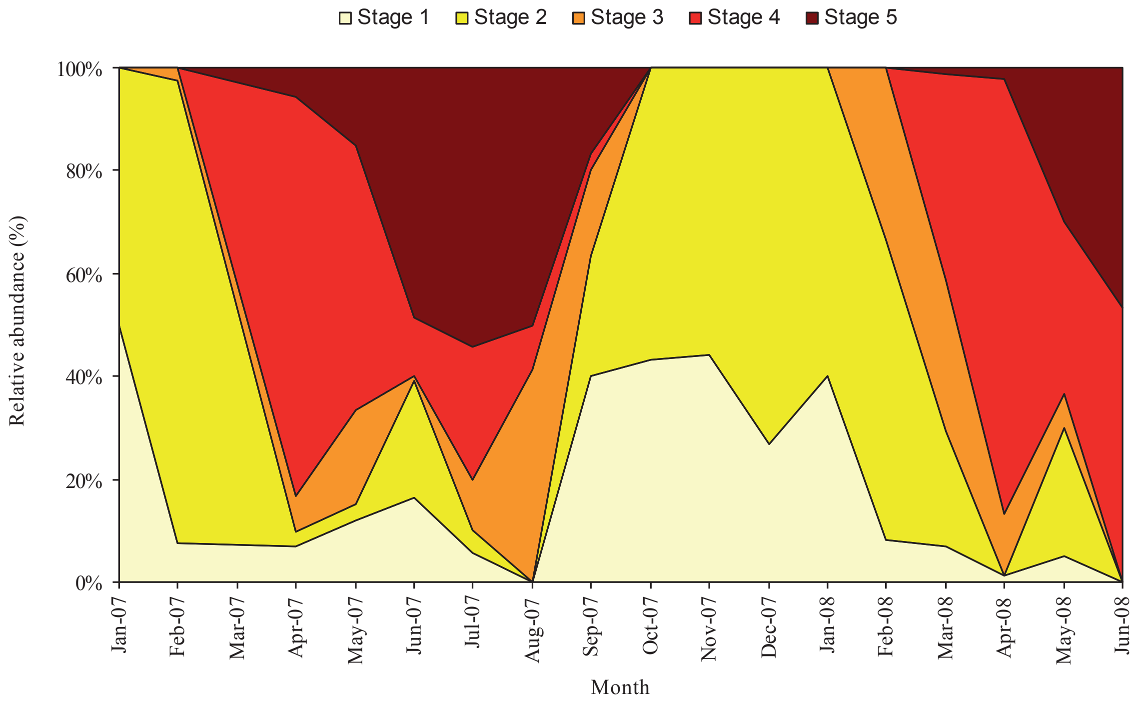

Figure 8. Gonad maturation stages of sand smelt according to Holden and Raitt (1974, modified) observed in two years of sampling in the wild in the Lesina lagoon. Legend: Stage 1 (Immature); Stage 2 (Maturing virgin and recovering spent); Stage 3 (Ripening); Stage 4 (Ripe); Stage 5 (Spent).

References

Andreu-Soler A, Oliva-Paterna FJ, Fernandez-Delgado C, Torralva M 2003. Age and growth of the sand smelt, *Atherina boyeri* (Risso, 1810), in the Mar Menor coastal lagoon (SE Iberian Peninsula). *Journal of Applied Ichthyology* 19: 202–208.

Bartulovic V, Lucic D, Conides A, Glamuzina B, Dulcic J, Hafner D, Batistic M 2004. Food of sand smelt, *Atherina boyeri* (Risso, 1810 Pisces: Atherinidae) in the estuary of the Mala Neretva river (middle-eastern Adriatic, Croazia). *Scientia Marina* 68: 597-603.

Bartulović V, Glamuzina B, Conides A, Dulčić J, Lučić D, Njire J, Kožul V 2004. Age, growth, mortality and sex ratio of sand smelt, *Atherina boyeri* Risso, 1810 (Pisces: Atherinidae) in the estuary of the Mala Neretva River (middle-eastern Adriatic, Croatia). *Journal of Applied Ichthyology* 20: 427-430.

Holden MJ, Raitt DFS 1974. Manual of fisheries science. Part 2. *Methods of resource investigation and their application*. FAO Fishing Technical Papers (115) Rev.1. 214 pp.

Koutrakis ET, Kamidis NI, Leonardos ID 2004. Age, growth and mortality of a semi-isolated lagoon population of sand smelt, *Atherina boyeri* (Risso, 1810) (Pisces: Atherinidae) in an estuarine system of northern Greece. *Journal of Applied Ichthyology* 20: 427-430.

Leonardos I, Sinis A 2000. Age, growth and mortality of *Atherina boyeri* Risso, 1810 (Pisces: Atherinidae) in the Mesolongi and Etolikon lagoons (W. Greece). Fisheries

Research 45: 81-91.
Maci S, Basset A 2009. Composition, structural characteristics and temporal patterns of fish assemblages in non-tidal Mediterranean lagoons: A case study. *Estuarine, Coastal and Shelf Science* 83: 602-612.
Moretti G, Gianotti FS, Giganti A 1958. *Il latterino (Atherina mochon) Cuv. nel Trasimeno*. Istituto di Idrobiologia e Pescicoltura, Università di Perugia, Tesi di laurea.
Trabelsi AG, Fleury C, Mâamouri F, Quignard JP, Faure E 2002. *Atherina punctata* and *Atherina lagunae* (Pisces, Atherinidae), new species found in the Mediterranean Sea. 2. Molecular investigations of three Atherinid species. *Comptes Rendus Biologies* 325: 1119-1128.
Trabelsi M, Kartas F, Quignard JP 1994. Comparaison du regime alimentare d'une population marine et d'une population lagunare d'*Atherina boyeri* des cotes tunisiennes. *Vie Milieu* 44: 117-123.
Trabelsi M, Maamouri F, Quignard JP, Boussaid M, Faure E 2004. Morphometric or morpho-anatomal and genetic investigations highlight allopatric speciation in Western Mediterranean lagoons within the *Atherina* lagunae species *(Teleostei, Atherinidae)*. *Estuarine, Coastal and Shelf Science* 61: 713-723.
Trotta P 1994. La pesca, la qualità delle acque, gli scarichi in laguna. *Atti del convegno La laguna di Lesina: quali prospettive, quali soluzioni?, Lesina*: 11-21.