

Eel, *Anguilla anguilla* (L.), in Italy: recruitment, fisheries and aquaculture

Eleonora Ciccotti, Sara Busilacchi & Stefano Cataudella

Laboratorio di Ecologia Sperimentale e Acquacoltura,
Biology Department, University 'Tor Vergata', via della Ricerca Scientifica s.n.c., 00133 Rome, Italy
ciccotti@uniroma2.it

Abstract

An overview of the status of eel, *Anguilla anguilla* (L.), stocks in Italy is presented, in order to evaluate possible connections between recruitment, exploitation by fisheries and needs of the eel aquaculture industry.

Data on glass eel fisheries, although partial and relative only to coastal waters, demonstrate that this fishery is going into rapid decline due to decreasing recruitment. The contraction of coastal lagoon fishery yields and the reduction of extensive culture production in the Venetian valli are partly related to the fall in recruitment. Freshwater stocks are apparently less affected by scarce recruitment because most significant stocks (i.e. lake fisheries) are sustained by restocking.

A series of priorities for a national management strategy is outlined, based on these main features.

Keywords: eel, glass eel, *Anguilla anguilla*, fisheries, management.

Introduction

Eel, *Anguilla anguilla* (L.), exploitation in Italy has a long-standing tradition, including fisheries for all continental stages, i.e. glass eel, yellow and migratory silver eel.

The eel has been an important commercial species in Italy since 1300, when it was first extensively reared by means of managed fisheries in the Venetian lagoons. The Comacchio valli reached a peak in prosperity in 1800 due to the eel fishery and processing industry.

In the nineteenth and early twentieth centuries, the North Adriatic area was very important and glass eel ascent, together with the juvenile migrations of other euryhaline finfish, guaranteed the natural seeding source for the valli and the coastal lagoons. Glass eel exploitation has always been intense also along the Tyrrhenian coast, in Tuscany and Latium. The yield was used for both seeding purposes and direct consumption, especially in Tuscany where glass eels were (and are today, even if illegal) a traditional delicacy. For this reason, poaching has always been a frequent occurrence.

In the 1960s and 70s, glass eel fisheries increased in number and were better organised, following the rise in demand from the aquaculture sector. Seed demand increased for restocking coastal lagoons, because spontaneous ascent lowered due to changing ecological conditions of these environments. Therefore, intensive aquaculture began to develop. Nowadays most of the eel production comes from this sector, Italy being the main producer in Europe, constituting nearly 40% of European production.

Eel fisheries in inland waters are set up in lakes and some rivers. Inland fisheries play a minor role as compared to the coastal lagoon fisheries. The latter environment covers around 150 000 ha, of which approximately 61 000 ha are presently exploited.

A series of problems, such as the reduction in adult catches in many ecosystems and the wide-spread recruitment decline all over the European continent, is causing concern for the future of the eel industry in Italy. At the same time, attention is turning to wild stocks, in relation to habitat losses and environmental degradation, and hence to the necessity of stock management on a local basis.

The present paper contains an overview of the status of eel stocks in Italy. Attention has been given to the evaluation of possible connections between recruitment, stock exploitation by fisheries and needs of the eel aquaculture industry.

Methods

The present work was carried out as a part of a research project of the Italian Ministry of Agriculture (Ministero per le Politiche Agricole, MIPA) on the sustainability of finfish fry fisheries in Italy. Three different units were involved, the target species of the present unit being the eel, *Anguilla anguilla*. The project sought to review all available data on the main biological and economic features of eel stocks in Italy, in order to provide the Administration with the necessary background to outline a sustainable management strategy for eel at the national level, possibly within a continental framework.

In order to build up an outline of eel yields from the different sectors, all official data were collected, from published statistics or from appropriate authorities.

Building up a complete picture of the present situation of the glass eel fisheries proved very difficult for many reasons. Fishing takes place in the transition area between sea and inland waters under two different Administrations. The Ministry of Agriculture controls salt and brackish waters, while inland waters are the responsibility of local Administrations, i.e. regions or provinces. In both departments a licence is necessary, which has to be renewed annually, in which quantities to be fished have to be declared. Fishermen must notify their catches and sales. The destination of glass eels ought to be restricted to aquaculture and restocking purposes, but the black market in some regions remains a problem. In the absence of counterchecks, collection of data can be partial, and their reliability doubtful.

Despite this, data on licenses, required quantities and catch returns were collected from the Ministry of Agriculture regarding coastal waters, while data have been requested from local Administrations in order to build up a picture of glass eel fisheries in inland waters.

With regard to eel yields from fisheries and aquaculture, statistics were collected and compared from different sources, i.e. the Istituto Italiano di Statistica, ISTAT (1996), relative to inland waters and coastal lagoons, and FAO (1999). In order to verify a series of features such as methods, yields, local management strategies, needs and perspectives, interviews were carried out directly with representative of provinces and regions, institutions, private companies and fish farms all over Italy.

The present paper is an extract from a national report where the results of the investigations are extensively reported (MIPA 1997, Ciccotti *et al.* 1999).

Results

1. Glass eel fisheries and recruitment

Glass eel fishing is carried out in estuaries, lower reaches of rivers at channel mouths and lagoon openings. At the moment, most of the glass eel yield comes from the Central and Southern Tyrrhenian area. The main sites of glass eel catches are the estuaries of rivers such as the Arno and Ombrone in Tuscany, the Tiber and the Garigliano in the Latium, and the Volturno and Sele in the Campania region. Those sites are frequented not only by local fishermen but occasionally also by fry fishermen from other regions, who reach those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, sea bream and eel fry. Local fishermen are usually single or co-operative fishermen, equipped with boats and structures to store the product alive. Fishing instruments vary depending on the characteristics of the site. Dip nets are used often in Tuscany, but usually glass eel fishing is carried out with fyke nets of varying dimensions, which are often provided with wings.

Despite the fact that direct consumption is forbidden, and that the destination of glass eels ought to be seeding for aquaculture or restocking, a certain amount of glass eels for consumption reaches the traditional markets of Pisa, Livorno, Viareggio and Lucca. This black market exists for three reasons namely: glass eels for consumption provide greater profit to the fishermen; wild glass eels have lower survival rates as seed than weaned elvers or fingerlings from France and Denmark; and even where glass eels are requested for seeding, due to scarce recruitment it is difficult for individual groups of fishermen to obtain sufficient quantities to satisfy the demand.

The number of licenses issued by the Ministry for coastal waters from 1989 to 1999 (Figure 1) demonstrates a decrease in fishing effort, probably due to a progressive drop in yields.

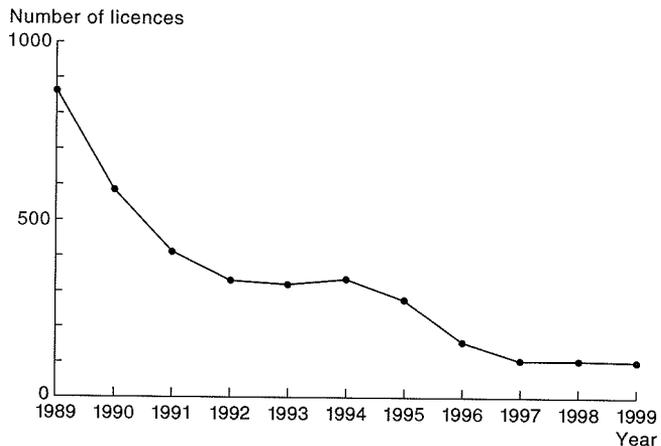


Figure 1. Number of licenses issued for glass eel fishing in coastal waters from 1989 to 1999.

The number of fishing sites for which there has been application has drastically reduced: in the '80s the applications were made for all the Maritime Departments (four sites on the Adriatic, two on the Ionian Sea and eight on the Tyrrhenian). In 1999, applications were for one site (Chioggia) in the North Adriatic and one on the Central Tyrrhenian (Livorno).

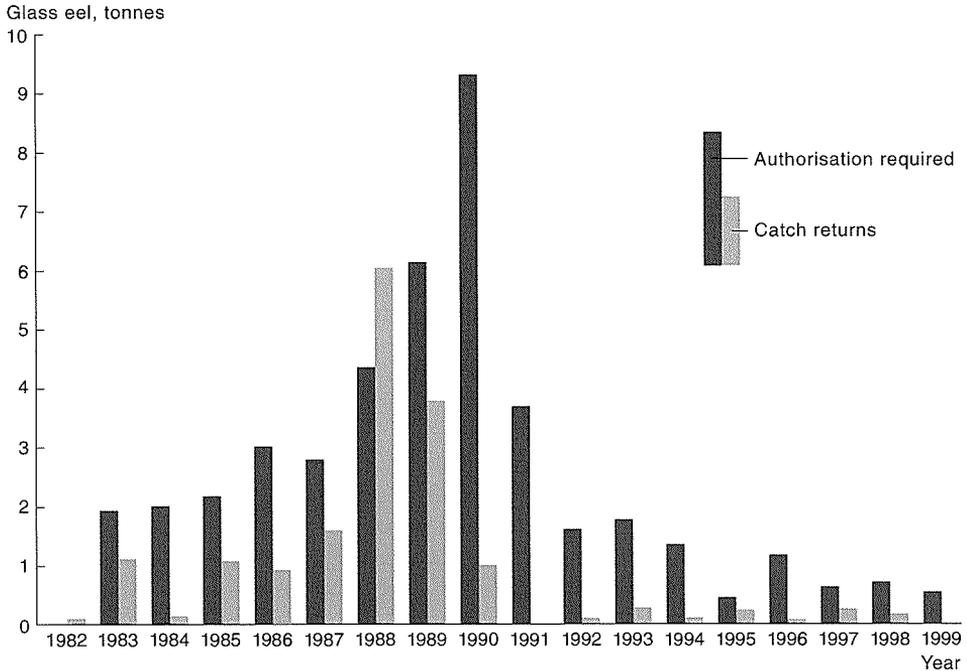


Figure 2. Quantities for which authorisation is required and catch returns, from 1982 to 1999.

Data of fishable quantities (Figure 2) can be considered indicative of the market demand, while catch return data are only roughly indicative of real catches. On the whole, it can be inferred from those data that the glass eel fishery is no longer profitable despite the increase in demand and in prices. However, it must be said that these data relate to coastal waters. Cumulative data from inland water glass eel fisheries are not available at present, but a similar evolutionary pattern has probably occurred. Without doubt, the larger share of glass eel yield comes from fresh waters (Latium, Tuscany and Campania rivers). Here it is particularly difficult to carry out evaluations because of high rates of poaching, i.e., single persons fishing without licence and selling glass eels on a personal basis (Franzoi & Rossi 1997).

Ingle (1988) estimated a ratio of 1:6:3.5 respectively for coastal fisheries, inland fisheries and imported seed. The same proportion is probably still applicable today, even if imported seed (wild glass eels, weaned elvers and small eels) is becoming more important on the Italian market.

2. Inland waters fisheries

Inland fisheries are found in main rivers and lakes. Most of the eel catches are from the great alpine lakes in the Northern regions, but the eel is also an important target species for professional fisheries in some volcanic lakes of Central Italy.

Each region has its own regulations. As a rule, individual professional fishing licences, which are valid for six years, are issued by the region, and are enlisted in registers kept by the provinces. The permitted gears vary from region to region, also in relation to local traditions, and are specified by each administration together with auth-

orised times and places. For the nets, mesh sizes and minimum and maximum dimensions of gears are listed.

Official statistics consider only eel catches in lakes and artificial basins, riverine catches being probably worthless. It must be borne in mind that statistics consider only professional fisheries. Catches from anglers are, however, possibly quite significant.

The inland waters eel catches from 1969 to 1996 are shown in Figure 3. The annual yield was always between 325 and 750 tonnes until 1987, while in the last ten years average yields have been less than 400 tonnes, except for years 1995 and 1996 (ISTAT, 1996).

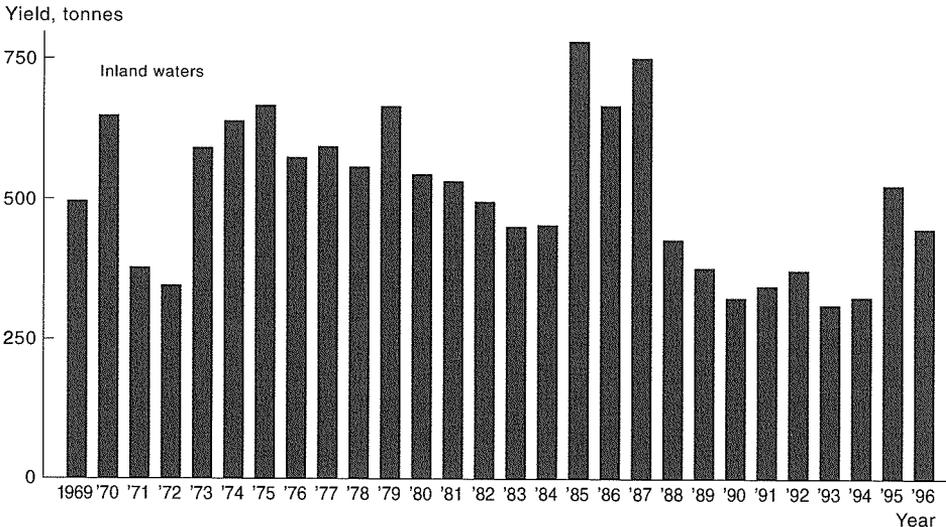


Figure 3. Eel yields in inland waters from 1969 to 1996. Data refer to lakes and artificial basins (source: Istituto Nazionale di Statistica, Annals of Hunting and Fisheries Statistics).

Decrease in habitat quality (pollution, eutrophication) and reduced habitat availability due to barriers seem to have affected local stocks, mainly in rivers, but a contraction of captures is not so evident at national level. Despite a slight decrease in the last decade, annual average yield is still about 400 tonnes. This is probably due to the fact that in many catchments eel stocks are sustained by restocking. The practice of restocking is quite wide-spread in inland waters. Besides restocking practised to sustain lake fisheries, maintenance restocking programmes adopted by the fishery commissions are periodically carried out by the provincial administrations with eels bought from dealers or from aquaculture plants. Complementary or extraordinary restockings can also be carried out by anglers' associations in the basins or river stretches they hold in concession. Restocking is rarely undertaken with full consideration of factors such as biological characteristics of the species or environmental aspects such as ecological diagnosis or carrying capacities. Problems can arise with seed availability and quality, particularly relating to transferable diseases and parasites, including *Anguillicola* sp.

3. Coastal lagoons fisheries

Most of the yield of yellow and silver eel fisheries comes from coastal lagoon environments, from both extensive culture and local fisheries.

The 'vallicoltura' practised in the upper Adriatic lagoons is one of the most ancient forms of aquaculture. Target species include, besides the eel, many euryhaline species such as mullets, sea bass and sea bream. The main difference from coastal lagoon management practised in other similar environments is that the 'vallicoltura' is run using artificial fry stocking and active hydraulic management. Most of the fishing takes place at the 'lavorieri', which are traditional fish barriers, based on the principle of V-shaped traps, whose structure, dimension and design have evolved greatly through the centuries. In other coastal lagoon environments, such as the Sardinian ponds, artisanal fisheries also exist inside the lagoons, and in the past management was mostly based on natural fry ascent and often lacked hydraulic management. This is not always possible today because of the ecological degradation of these environments.

Fishing equipment for eel catches besides the fish barrier, useful for catching silver eel in winter, includes a variety of other instruments ranging from single fyke nets to groups of fyke nets, long lines, traps and baskets, depending on the sites, local traditions, and particular skills of local fishermen.

Statistics on eel production in lagoon environments from 1969 to 1996 are reported in Figure 4. Data should only refer to lagoon fisheries, while extensive culture productions such as the vallicoltura yields ought to fall within the aquaculture productions (see next section, Figure 5). It is possible, however, that overlap occurs between these data.

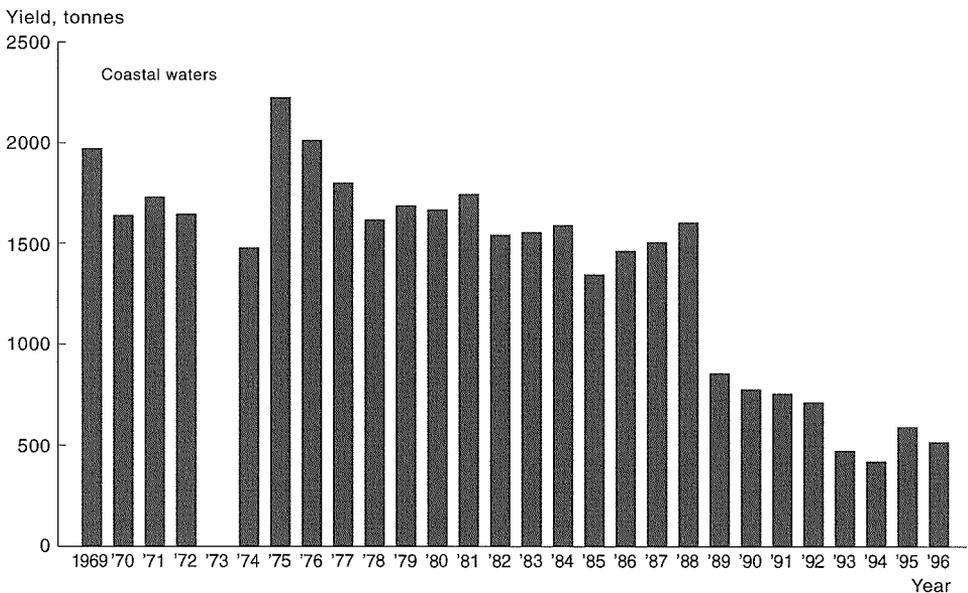


Figure 4. Eel yields in coastal waters from 1969 to 1996 (source: Istituto Nazionale di Statistica, *Annals of Hunting and Fisheries Statistics*).

A decreasing trend is evident, which took place during the '80s, with yields decreasing from an average of 1500 tonnes in the '70s to about 500 tonnes in the '90s.

The main limiting factor in eel production in lagoons today, apart from the habitat changes related to coastal waters eutrophication and pollution, is seed availability for stocking. National glass eel catches are used for lagoon restocking, and the fall in re-

cruitment and the consequent decline of glass eel fisheries cannot be compensated for by imported seed, because of increased prices. This, together with the fact that the eel life cycle in lagoons is long (average seven years) and hence non-competitive with the aquaculture product, means that other species are given preference when local management strategies are formulated.

4. Aquaculture

Intensive eel culture plays a major role within the national context. This started in the 1970s when yields decreased in extensive production. The need to recover former production levels induced many producers to try the intensive technology. First attempts were based on Japanese technology, modified to suit the local realities.

Present-day technology is highly variable, but eel culture is usually carried out in fresh water, at temperatures ranging between 20 and 28°C, in open concrete or earthen ponds, with or without supplementary oxygenation depending on the densities. These are never lower than 0.5 kg/m², and can reach 20 kg/m², depending on water availability. In recent years, many farms have invested in recirculation systems based on Danish technology, aimed at improving performances and reducing impacts on the environment.

The limiting factor for most industries has become seed availability and its high costs. Seed consists mostly of small eels (5-20 g). A choice must be made between nationally caught or imported wild seed, which often performs poorly due to prolonged storage or transport, and weaned seed, i.e. elvers and small eels mostly imported from France and Denmark, which are expensive but give good returns. Wild glass eels are seldom used, except in fish farms which are equipped with the necessary structures and technology to wean these to feeding stages.

Production data from 1984 to 1997 are reported in Figure 5. Statistics comprise intensive aquaculture and extensive culture, the latter referring mostly to vallicoltura. Extensive production has progressively decreased in the last decade. The slight increase

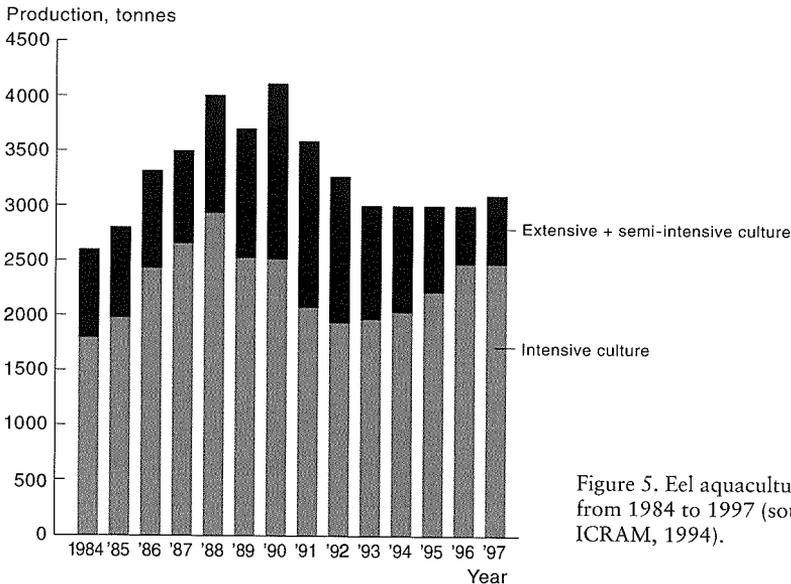


Figure 5. Eel aquaculture productions from 1984 to 1997 (source: FAO 1999, ICRAM, 1994).

observed in 1990-92 is due to the development of semi-intensive technology, to make up for the problems of the extensive sector. In this rearing method, eel are reared in open, wide-surface basins, and at low stocking densities but with additional feeding.

The semi-intensive technology has not proved to be completely successful, mainly because of the environmental impact it can have on the fragile ecosystems found in coastal lagoons and valli.

Intensive aquaculture shows a constant growth in the course of the '80s, followed by a plateau in the early '90s. At present, capacity seems to have reached saturation. Eel production is still the highest in Europe, covering almost half of the total European aquaculture yield, which has been estimated at about 7600 tonnes (FAO, 1999). Most (almost 90) of the intensive farms are found in Northern Italy, while in the South there are about 30 eel farms, most of which have been recently built or converted from other activities.

Discussion

The overview on the status of eel stocks in Italy highlights certain features.

Data on glass eel fisheries, although partial and relative only to the sector of coastal waters (i.e. estuaries), demonstrate that this fishery is going into rapid decline and is at risk of total disappearance. This is clearly due to falling recruitment, also confirmed by the trend of the time-series observed on the Tiber estuary, the only site in Italy where constant monitoring has been carried out (Ciccotti *et al.* 1998a, 1998b). A strong market for glass eels remains, owing to interest from the aquaculture sector and also for restocking purposes.

The infrequency and lowering of yields makes them subject to sale for direct consumption on the black market. This in turn hampers the monitoring and the collection of consistent time series of recruitment on a national basis.

The contraction of coastal lagoon fishery yields and the reduction of extensive culture production in the Venetian valli are partly related to declining recruitment. In many lagoon environments, nevertheless, reduction of habitat quality due to eutrophication and pollution also play a role, together with local management problems (Cataudella & Rossi 1998, Ciccotti 1997).

Freshwater stocks are apparently less affected by scarce recruitment, but this is due to the fact that most significant stocks (i.e. lake fisheries) are sustained by restocking. Incomplete data suggest that local stocks have been affected by habitat reduction due to dams, while there is some doubt as to whether stocks have been affected by the general decrease in habitat quality.

Intensive eel aquaculture is very important because it has replaced the extensive sector in Italy. However, it is at present strongly limited by scarce seed availability and by its high costs.

By taking into account these data, a series of priorities for a national management strategy can be singled out at different levels. These options have been dealt with extensively in a national report and in some papers (Ciccotti *et al.* 1998c, Ciccotti *et al.* 1999), and can be summarised thus:

- i. Establishment of a long-term monitoring program for glass eel fisheries, all over Italy. The Ministry of Agriculture is at present supporting a research project aimed at the setting-up of a monitoring system for glass eel fisheries on a national basis.

- ii. Revision of the regulations regarding glass eel fisheries, and providing incentives for a centralised system of stocking and commercialisation of glass eels, in order to safeguard professionals and discourage illegal markets.
- iii. Restoration of the inland water stocks, by actively involving the professional fishermen in restocking practices.
- iv. Recovery of the traditional role of coastal lagoons, and their involvement in the management of the eel stock, for example defining escapement targets of mature silver eel.
- v. Integration of the fisheries and aquaculture sectors in the management process, with a view to involving them directly in the eel management.

More generally, and on a larger scale, it will be necessary to intensify research on the features of eel biology which are useful for management, following international guidelines as they emerge.

Acknowledgements

The Authors are grateful to the many employees of Province Administrations, the General Directorate for Fisheries of the Ministry of Agriculture, ICRAM, ISTAT, fish farms and fishermen Cooperatives that gave assistance during the present work. Special thanks go to Dr Alessandro Perolo and to Prof. Remigio Rossi.

References

- Cataudella, S. & R. Rossi, 1998.* Considerazioni generali sulle Valli di Comacchio nell'ambito di politiche ambientali di nuova generazione. – *In* Risanamento e tutela delle Valli di Comacchio fra conservazione ambientale e valorizzazione produttiva. *Laguna 5 (suppl.): 77-82.* In Italian.
- Ciccotti, E., 1997.* Italy. – *In* C. Moriarty & W. Dekker (eds): *Management of the European eel.* *Fisheries Bulletin (Ireland), vol. 15: 91-100.*
- Ciccotti, E., T. Ricci, M. Scardi, E. Fresi, E. Cataldi & S. Cataudella, 1998a.* Euryhaline finfish fry evaluation in permanent observatories at the mouth of the Tiber river. *Biologia Marina Mediterranea 5(3): 574-580.*
- Ciccotti, E., S. Busilacchi, A. Loy, F. Riccardi, M. Scardi & S. Cataudella, 1998b.* Sustainable use of finfish fry at the Tiber river mouth: the case of glass eel. *Biologia Marina Mediterranea 5(3): 581-592.*
- Ciccotti, E., S. Busilacchi & S. Cataudella, 1998c.* Bio-economic analysis on wild finfish seed: the case of glass eel. *Biologia Marina Mediterranea 5(3): 593-602.*
- Ciccotti, E., S. Busilacchi & S. Cataudella, 1999.* La pesca delle ceche di anguilla, tra conservazione ed uso responsabile di questa specie migratrice. *Laguna, 6/99 (suppl.): 94-12.* In Italian.
- FAO, 1999.* Aquaculture production statistics 1988-1997. – *FAO Fisheries Circular n. 815, rev. 11.* Roma, FAO, 1999. 203 pp.
- Franzoi, P. & R. Rossi, 1997.* Valutazione, ai fini gestionali, degli stocks di novellame di specie ittiche eurialine destinate all'allevamento. – *Terzo piano triennale 1993-1996, legge 41/82, Ministero delle Risorse Agricole, Alimentari e Forestali.* 187 pp. In Italian.
- Ingle, E., 1988.* Allevamento larvale di pesci marini: realtà e problematiche per lo sviluppo del settore. – *Il Pesce, 5 (4): 31-36.* In Italian.
- ISTAT, 1996.* *Annali delle Statistiche della Caccia della Pesca.* In Italian.
- MIPA (Ministero per le Politiche Agricole, Direzione Generale della Pesca e dell'Acquacoltura), 1997.* – *Quarto Piano Triennale, 1997. Programma di Ricerca: 'Pesca del Novellame da Allevamento: Valutazione dell'Impatto Sulle Risorse Biologiche e dell'Impatto Socio-Economico'* [Bio-economic analysis on wild fin seed: the case of glass-eel] *Relazione Finale, Maggio 1997.* 83 pp. In Italian.