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MEDITERRANEAN COASTAL LAGOONS: SUSTAINABLE MANAGEMENT AND INTERACTIONS AMONG AQUACULTURE, CAPTURE FISHERIES AND THE ENVIRONMENT

GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

CASE STUDY 3. STATE OF THE RESOURCE AND EXPLOITATION OF THE EUROPEAN EEL (*ANGUILLA ANGUILLA*, LINNEO 1758) AND ELEMENTS FOR THE PREPARATION OF A COMMON MANAGEMENT PLAN IN THE GFCM AREA

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Biology and behaviour of the European eel

The European eel is known to spawn in the Sargasso Sea and its larvae cross the Atlantic Ocean and enter the European and north-African inland waters and lagoons. Several years after, the adults backcross the Atlantic to spawn. However, neither specimen ready to spawn nor the spawning itself, which is supposed to occur at more than 2000 m depth, were ever observed. Nowadays, it is admitted that the population of this species is panmictic and that its distribution area extends from the Barentz Sea down to Mauritania and comprises the Mediterranean and the Black Sea; it is therefore a resource shared by all northern European and Mediterranean countries.

Recent works in the field of genetics reconsider the panmictic hypopthesis and recognize three different groups: the north European eels, the western European eels and the Mediterranean ones (Van Ginneken and Maes, 2005) but this theory is not accepted everywhere (Palm *et al.,* 2009). It is generally admitted that the greatest number of larvae are transported across the Atlantic ocean by the main branch of the Gulf Stream and then by the North Atlantic drift. The Azores current transports them to the Mediterranean while the northern branch of the North Atlantic drift sends them to the eastern part of the distribution area, and the southern branch transports the larvae to the central part of the European coasts (Schmidt, 1909; Kracht, 1982; Kettle, 2005).

During their journey they feed on zooplankton by making vertical migrations between 35 and 600 m deep. They reach the European coast in spring, and the northern sectors at the end of the summer at a size of 75-90 mm (Bertin, 1951; Elie, 1979). According to the authors, their transatlantic journey can last between 6 months and two years.

In the Mediterranean, the post larvae ("glass eels") are encountered along the coastline from January to December with peaks of abundance from December to April (Lefevre *et al.*, 2003). Eels continue to grow for 10–14 years until they reach a size of 60 to 80 cm; during this phase of life they are called "yellow eels" ("green eels" in the Mediterranean) because of the golden pigmentation mixed in the black pigment. The growth is variable according to the geographical zone where they live: they grow faster in the south than in the north of the species' distribution area. The growth is slower for the animals reaching the top of the streams where the individuals stay longer (more than 15 years and sometimes 20 years) and are generally females. Eels grow faster in the lagoons, which generally produce male individuals, migrating more prematurely offshore between 3 years and 7-8 years of age, according to the latitudes. These adults («silver eels») leave the coasts of European and North African coasts in autumn, and ripening, i.e. gametogenesis, takes place during the east to west transatlantic migration using the Canary islands and northern equatorial currents to reach the spawning areas of the Sargasso sea during the first half of the following year (Farrugio and Elie, 2011).

Fisheries statistics

In the Mediterranean, adult eels are mainly exploited by artisanal fisheries in inland waters (estuaries, lakes and rivers) and in the coastal lagoons of the border countries.

In most of the Mediterranean countries, eels are fished mainly using various types of traps: fixed or mobile gear like fyke nets (Figure 1) or fixed traps installed in the channels between the lagoons and the sea, which allow to manage the inputs or outputs of the fishes.

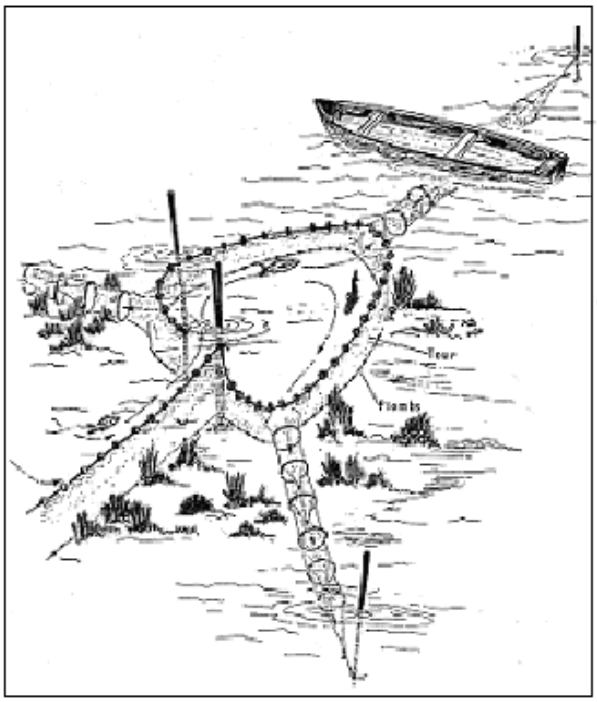

Figure 1. Fyke net for eel fishing in the Mediterranean lagoons

In most countries, the catch and effort statistics on eel are often absent or not regularly collected, however according to the FAO Fishstat database the overall production of European eel has dropped drastically since the mid-1980s.

During the first half of the twentieth century the overall production of European eel was several times greater than 50 000 tonnes, and then it has rapidly dropped starting from the 1960s. This production ranged from 10 000 to 13 000 tonnes during the 1980s and then regularly decreased down to 3 200 tonnes in 2007. A drastic decrease of more than 90 percent has been observed for the landings of glass eels along the European coasts (Fig. 2: Dekker, 1998; 2003; 2004).

In the Mediterranean, eel production comes essentially from the lagoons and there is no doubt that they represent an important economic activity, but up to now it is still very difficult to quantify it accurately. Generally, glass eel fishing is prohibited in the Mediterranean bordering countries but poaching and important illegal catches of undersized juveniles exist in some places.

In France, according to the most recent estimations, eel fishery occupies approximately 600 professionals. Eel can represent 20 to 80 percent of the total production of a lagoon according to sites. The available statistical data indicate that the total production of French lagoons, which was around 1 500 – 2 000 tonnes a year in the 1980s (Elie and Rigaud, 1984) showed a marked decline and then stabilized around 1 000 tonnes/year since the end of the 1990s.

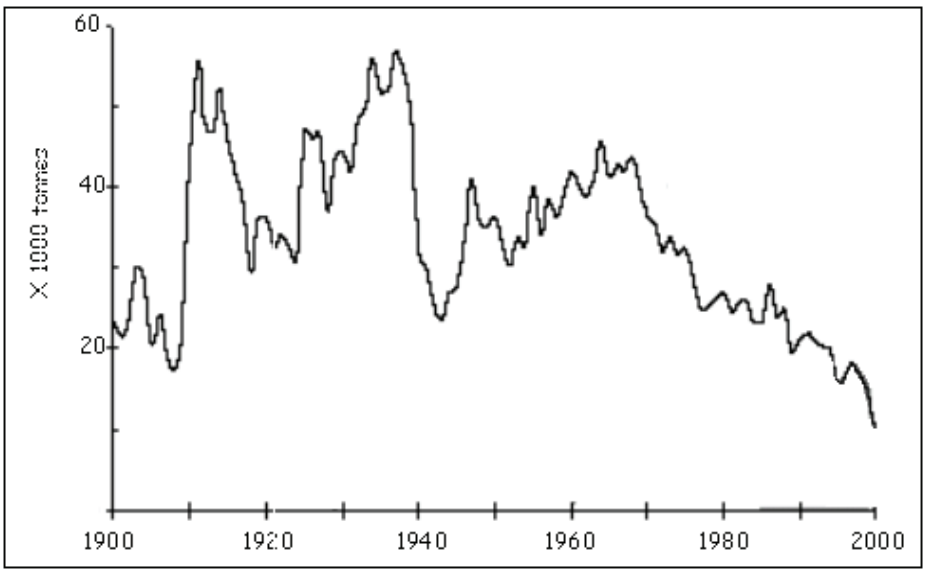

Figure 2. Evolution of the European eel catches during the 20th century
(Source: Decker, 2004)

In Italy, the most productive region is the Venetian region, which produced approximately 450 tonnes a year in 1975–1976. The total production of Italian lagoons was around 1 500–2 000 tonnes/year during the 1970–1980s. Then it decreased very strongly down to 500 tonnes in the 1990s and then around 200 tonnes in the last decade (Anon, 2002).

In Greece, production of European eel (captures plus fish farming) varied from 300 tonnes in 1980 to 1 000 tonnes in 2001. This is the result of a considerable increase of aquaculture production and of a very sensitive simultaneous decrease of the global product of the lagoon fishery, which declined from the years 1988–1998 although the individual production of some coastal lagoons and the one of inner lakes increased during the period 1990–2000 (Koutsikopoulos *et al.*, 2009).

In Spain, a study on the production of Andalusia showed that in certain sectors eel population decreased by 98 percent (Aguilar *et al.*, 2008). Also in Turkey the population of European eel decreased drastically during the last decades (Yalçın *et al.,* 2006).

In Tunisian lagoons, eel production was around 1 000 tonnes in the 1970s and 1980s and the importance of captures did not stop declining since then, down to an average of 180 tonnes/year for the period 2000–2009. In Algeria, till the beginning of the 1990s, the production of the El Mellah lagoon was dominated by eels, which represented 50 to more than 80 percent of the contributions of the fishery, then this proportion decreased by more than 80 percent. The yearly average production indicated in the region of El Kala during the last decade was of the order of 80 tonnes (Romdhane, 1985; Chaouchi, 1995).

The FAO-FISHSTAT data for the GFCM area show that the overall Mediterranean production followed the worldwide trend and decreased from yearly catches of around 4 000-5 000 tonnes in the 1980s to 1 000 tonnes in 2000 and 700 tonnes in 2007 (Fig. 3, FAO, 2009). According to these statistics, with the exception of the Egyptian data, the five main producer countries are respectively Italy (46 percent of the total), France (26 percent), Turkey (13 percent), Tunisia (9 percent) and Albania (2.6 percent).

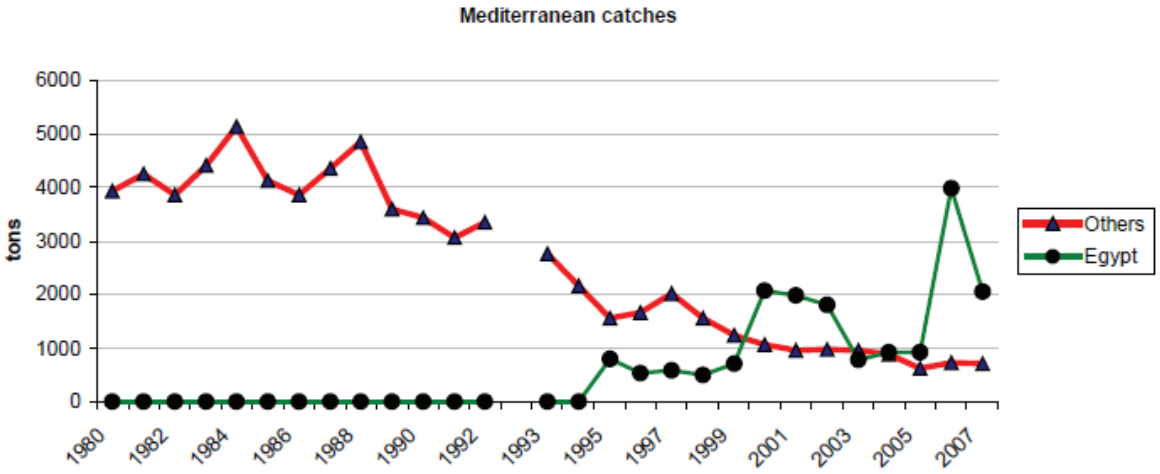

Figure 3. Recent Mediterranean catches of European eel (Source: FAO, 2009)

Factors affecting eel populations

Some results (profits) stemming from comparative studies on fish populations show that the eel is the species that accumulates the biggest quantity of organic and inorganic pollutants of various origins like PCBs (Ashley *et al.*, 2003; Tapie *et al.*, 2006; 2010), HAPs (Roche *et al.*, 2000; 2001; 2002) and heavy metals (Durrieu *et al.*, 2006; Pierron *et al.,* 2007, 2008). Furthermore, as the eel is situated at the top of food chains, it can present strong levels of contamination due to the mechanisms of bioaccumulation existing in the trophic web. It is considered that the environmental quality strongly contributed to the decrease of the species productivity. The decline of eel populations is due to several additive factors. They can be of marine origin (changes in oceanic currents, reduction of the ocean productivity, etc.) or be due to changes in the continental part of the biological cycle of the species: obstacles to migrations, degradation of large parts of the habitats, fishing activities and diseases (Elie and Rigaud, 1984; Vigier, 1990; 1997; Bruslé, 1994; Moriarty and Dekker, 1997). Among the activities that have favoured the decline is the setting up of dams for the building of hydroelectric plants, which represent important obstacles to the migration as they limit the number of animals able to move upstream and downstream the rivers (Elie and Rigaud, 1984; Elie, 1997)

Parasitism is certainly one of the main causes of the decline. Since the early 1980s, 30 to 100 percent of the local eel populations are infected by *Anguillicola crassus*, a nematod blood parasite coming from Australia and southeastern Asia where it is harmless for the Japanese eel, *Anguilla japonica.* It seems that it has been introduced in the European aquaculture fattening plants with glass eels imported from Japan. It appeared in Italy in the early 1980s, in Germany in 1982 and in the French Mediterranean lagoons in 1984. In the early 1990s, it was found in the inland waters of North Africa, in Morocco, in Tunisia and in Egypt. However, the percentages of infected eels in African waters are lower than in the European ones. In 2002, *A. crassus* was observed in Turkey in the eels of the river Ceyhan.

Management objectives

It is known that the deterioration of the species habitats and the quality of its continental environment have largely decreased the productivity of the eel. According to the International Council for the Exploration of the Seas (ICES), the level of harvest of the species is unsustainable and since 2000 it has been added to the list of species of the annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The European eel has also been declared an endangered species by the IUCN.

Commercial trade is submitted to the setting up by exporting countries of a management plan showing, for each sector of the species distribution area, the state of the eel population, the

current regulations regarding its catches and its environment and also how to manage them in order to recover the species stock

The European Union asked to each of its member countries to prepare by the end of 2008 a management plan for each catchment basin inhabited by eels. The idea is to rebuild on the long term panmictic stock to reach the main objective of increasing the escapement to the Sargasso Sea of the potential spawners from each basin. The goal is to reach a spawning stock biomass (SSB) close to the average SSB of the 1970s, a period in which the recruitment of glass eels was situated at "normal" levels (Farrugio and Elie, 2011).

Logically, this result implies that it could be possible to act on all the species mortality factors of the eel. However, a very few number of studies currently exist on the production and the rate of escapement of silver eels, in particular from the lagoons inhabited by the main sub-populations in the Mediterranean region.

To reach this goal, it is also necessary to apply methodologies enabling the escapement of silver eels from rivers and lagoons to the open sea and enabling to evaluate their impact on the exploited population. A few studies have been carried out on the evaluation of the escapement rate and on silver eel population size and its exploitation rate. These works were based on the tagging and recapture technique using non-lethal dyes which could easily be applied in many sub areas (Farrugio *et al.*, 2006; Amilhat *et al.*, 2007).

The European Union is financing a group of experts belonging to the CEFAS to elaborate a synthesis on the pilot projects aimed at evaluating the current and possible escapement of silver eels. This group intends also to realize a synthesis on the various existing mathematical models and their domain of applicability.

The EU asked for the implementation of management plans to the countries exploiting eel in order to control trade and ensure traceability. These plans have to ensure an escapement of at least 40 percent of the pristine biomass of adults. To be approved by the EU, they have to describe the means to reach this goal and the methods to be used in order to estimate the efficiency of the plans. At present, 70 management plans have been submitted to the EU, 15 of which have already been approved. Among the Mediterranean southern countries, Tunisia presented a first draft and obtained a quota of export for eels in 2009. However, to stabilize its production and its resource, this country elaborated a complete plan of management which was subjected to the EC in November 2010.

Methods of analysis

Some mathematical models already exist to evaluate eel populations dynamics; they all give pessimistic diagnosis on the state of this resource. However, up to now, no one has taken into account the spatial diversity of the population and the fact that there could be a part of this population specific of the Mediterranean and that the biological and ecological characteristics are very different between the northern and southern parts of the distribution area.

The models on the Mediterranean eel population dynamics need to be improved in order to take in account all the various anthropic pressures and to assess the enforcement of new protection measures which could be adopted by the countries exploiting this resource.

However, in the current context of the research on eel in the GFCM area, much information, though necessary, is missing: elements on the demography of the populations living in the Mediterranean hydrosystems (size structures, age and sex compositions, growth parameters, quality of the animals in terms of pollution and parasitism, etc.), knowledge on the continental habitats, human pressure other than fishing, quality of the migrating specimen, quantities of chemical pollutants in the water and along the trophic web. Currently, these data do not exist in the GFCM database so it will be important as a first step to feed it with some preliminary elements and then to complete the information after having selected the relevant factors in the frame of the activities of the GFCM Scientific Committees.

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