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SCIENCE DIRECT
Fisheries Research 78 (2006) 72–88
FISHERIES RESEARCH
www.elsevier.com/locate/fishres

Biology and fishery of *Eledone cirrhosa* in the Ligurian Sea

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Abstract

Biological information for *Eledone cirrhosa* has been reassessed through two series of trawls in the framework of the Research Projects MEDITS (summer) and GRUND (autumn) over a 10-year period of surveys in the Ligurian Sea. This information covers aspects such as life span and growth and mortality rates. The sum of samples obtained in the two different seasons allowed the analysis of consistent length frequency distributions and resulted in distinguishing recruits/juveniles from adults of two different ages, i.e. *E. cirrhosa* is a relatively long living cephalopod, whose reproduction occurs in the second or third year of life. By sampling in different bathymetric strata, different densities on shelf and slope fishing grounds were measured and their displacements with changing season were monitored. The most important stratum in terms of summer densities was in the range 100–200 m depth, which includes the shelf edge, at 150 m. In a relatively narrow strip of seabed, covered by the shelf-edge detritic assemblage and adjacent muddy bottom assemblage VTC (80–150 m), the recruitment of *E. cirrhosa* occurs from January onwards, while till recent times a specific trawling targeting juveniles used to be carried out in late spring and summer months. In autumn *E. cirrhosa* is mainly concentrated in shallower waters where trawling activity does not specifically target this species.

Trends in numbers and biomass derived by the two series of surveys, and in particular those during autumn series have revealed a significant decrease over the studied time interval. Therefore, the possible relationship between large-scale environmental factors and/or exploitation, was investigated and a positive relationship between summer biomass and winter NAO index was found, even if the cause of such relationship remains unexplained. However, trends of *E. cirrhosa* landings reported in other studies of the north-western Mediterranean resulted in a similar relationship, thus reinforcing the hypothesis of climatic factors influencing the success of the fishery of this biological resource.

A tentative stock assessment, based on relative yield-per-recruit functions, taking into account the two different lengths at first capture and corresponding to mesh sizes of 20 or 40 mm (juveniles and adults nets), showed overexploitation and underexploitation, respectively. A preliminary study of density indices by vital phase also demonstrated a correlation between summer spawners and autumn juveniles of the following year, thus providing evidence of a stock–recruitment relationship.

Keywords: *Eledone cirrhosa*; Trawl surveys; Life span; Growth; Mortality rates; Assessment; Ligurian Sea; Mediterranean

1. Introduction

Morphology, physiology, behaviour of culture reared individuals of *E. cirrhosa* (Lamarck, 1798) and aspects of reproduction and growth have been the object of thorough studies both in the Mediterranean (Jatta, 1896; Naef, 1921–1923; Mangold-Wirz, 1963; Mangold et al., 1971) and in Northern Europe (Boyle, 1983; Boyle and Knobloch, 1982, 1983); while its ecology seems a little less known (Boyle, 1986) and apparent differences can be found between northern and southern populations.

E. cirrhosa in the Mediterranean is a medium sized species (maximum size less than 1 kg) and lives on muddy bottoms at circalittoral and bathyal levels (Mangold-Wirz, 1963). It has a reproductive period coinciding with spring-summer (from the end of May to the middle of August, according to Mangold-Wirz (1963); however, some individuals may reproduce in April (Mangold et al., 1971), though this is a less common case).

The northern form of *E. cirrhosa* is larger (to 2 kg) and lives in a wide range of depth from the shoreline to the slope (Boyle, 1983). It seems to have a very long reproductive period, since its planktonic stages have been found all year long (Boyle, 1983, quoting Russel, 1921 and Stephen, 1944) and it is trawled from flat bottoms of stones, sand and mud, but

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0165-7836/$ – see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.fishres.2005.12.008

is also common in rocky areas, where it often enters pots for lobsters and crabs, causing problems for this fishery (Boyle, 1983, 1986). In any case, it seems not to belong to a local tradition of food consumption, at least in Scotland and catches are often sold commercially at local markets for export to Mediterranean countries (Boyle, 1986).

In the Mediterranean given its deep habitat, *E. cirrhosa* appears to be subject to minor changes of hydrological characteristics such as salinity and temperature, at least in the Western sector of this area. In fact its distribution area extends both to neritic waters under the seasonal thermocline and on that part of the slope which is in contact with the Levantine intermediate water (LIW), a water mass characterized by a temperature of about 13.5 °C and a salinity of about 38.5‰ (Millot, 1999). Thus a relative uniformity of ecological traits can be envisaged; on the other side some differences in timing of reproduction have been recorded in the Aegean Sea (Tursi et al., 1995; Lefkaditou and Papaconstantinou, 1995) under hydrological conditions different from the present study area.

As one of the three most abundant commercial cephalopod species in the Mediterranean, *E. cirrhosa* has been the target of many specific studies. In recent years, trawl surveys aiming to assess demersal resources have taken place, both on an Italian (GRUND since 1985) and a European level (MEDITS since 1994). These research surveys constitute experimental trawling operations which have provided the opportunity to verify several aspects of the biology of *E. cirrhosa*, particularly maturation and growth, and to compare these features over large geographical areas. Results of the surveys above are available in several papers, both concerning all cephalopod species, or in particular the two species within the genus *Eledone*, and with information regarding assessment and management of *E. cirrhosa* (Belcari et al., 1990, 2002; Wurtz et al., 1992; Belcari and Sartor, 1993; Agnesi et al., 1998; Biagi et al., 1998; Relini et al., 1998a,b; Gonzales and Sanchez, 2002; Cuccu et al., 2003).

E. cirrhosa is known to be abundant in the Gulf of Genoa and in the Eastern Ligurian Sea (Leghorn), since the observations of Verany (1851). At present commercial trawling in the Ligurian Sea, carried out in the range 50–750 m depth, produces a very rich crop, in terms of species diversity and cephalopods can reach a quarter of the total fishery production with *E. cirrhosa* often representing about a half of this fraction.

E. cirrhosa appear, as very small recruits, in the catches of trawlers from January onwards (Relini and Orsi Relini, 1984). Juveniles become abundant enough to form a valuable portion of catches in late spring and, when trawling was targeted towards *E. cirrhosa*, the catch was sorted into three fractions, whose price is inversely related to the size.

The present paper reports indices of abundance and biomass in the Ligurian Sea from the MEDITS and GRUND surveys over the last 10 years, looks for trends in catches, analyses the size and age structure of the fished stock, suggests a model of growth, uses biological parameters in a tentative stock assessment in the study area and explores the influence of environmental factors on biomass indices of *E. cirrhosa*. The analysis of the length frequency distributions based on large numbers of individuals allowed explanation of new aspects of the life history of *E. cirrhosa*.

2. Materials and methods

2.1. Study area and commercial trawling activities regarding E. cirrhosa: previous studies

The study area (Fig. 1) is the Ligurian Sea, from the French borderline to the North of Gorgona Isle, with its shelf and slope trawling grounds. These are very narrow and steep in the Western sector, while the shelf is larger in the Eastern sector and also trawling activities are more profitable. The map shows shelf areas of about 2050 km^2 of which approximately 35% is not trawlable because the depth is less than 50 m (Italian trawl legal depth) and slope areas of about 3830 km^2 to the deepest accessible level, at about 700 m depth.

The trawl fishery of the four Ligurian harbour-office, Imperia, Savona, Genoa and La Spezia, has basic artisanal characteristics (different from other Mediterranean fisheries, see for instance the Catalan fleet in Sanchez and Martin (1993)). In fact, along 330 km of coast, a total of 64 trawlers (year 2003) are at present based in the ports of Sanremo, Imperia, Savona, Genoa, Santa Margherita, Sestri Levante and La Spezia. The trawlers have an average 27 gross tonnage and a power of 187.5 kW (IREPA, 2004), figures which are lower than the national average. Trawling is carried out with daily trips and particularly in the Eastern sector (Santa Margherita Ligure) only in daylight hours, according to habits that can be traced back to the 17th century (Scarsella, 1914).

The total annual catch of *E. cirrhosa* in the Italian seas is at present around 2500 t, after a serious decrease in recent years. The annual catch landed in Ligurian harbours is estimated to be about 190 t per year (IREPA, 2004). A study on landings of trawlers in the six main Ligurian harbours (Sanremo, Imperia, Savona in the Western sector, Santa Margherita, Sestri Levante, La Spezia in the eastern sector, see also Fig. 1), was made for the period 1995–1997 when the fleet was formed by 79 units (Bottero, 2001). The importance of the fraction of both total cephalopods and *E. cirrhosa* in the commercial product (calculated from mean daily landings per boat) was growing along a geographical gradient West-East, from Sanremo to Sestri Levante: in Sanremo Cephalopods represented the 16.4% of the total commercial product and *E. cirrhosa* the 5.7%; in Sestri Levante these two fractions were the 34.3% and 14.7%, respectively. In the last port, La Spezia, total Cephalopods resulted the 24.4% and *E. cirrhosa* 17.7%.

In the present study area previous studies on *E. cirrhosa* regarded landings at Imperia and Camogli (Wurtz and Repetto, 1983), reproduction and growth (Palumbo and Wurtz, 1983–1984; Relini et al., 1994), recruitment (Relini and Orsi Relini, 1984) and assessment (Relini et al., 1996).