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Comparison of the population structure and dynamics of *Aristeus antennatus* (Risso, 1816) between exploited and unexploited areas in the Mediterranean Sea

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Abstract

Data on the size distribution and population biology of the deep-water shrimp *Aristeus antennatus* were collected during four trawl surveys carried out along the Italian coasts (exploited area) and off north-western Greece (unexploited area). Comparison between the sampled populations was carried out in the 500–800 m depth range where trawl fishing, targeting deep-water shrimps (*A. antennatus* and *Aristaeomorpha foliacea*), occurs only along the Italian coasts. Some explorative hauls were also made as deep as about 1200 m. *A. antennatus* was collected down to 1122 m in the Italian area and 1174 m in Greek waters. It was found to be more abundant in the former area than in the latter. In both areas, the sex ratio was largely in favour of females and changed with depth. Maturity process by size was found to be similar in the two areas. Even though the median carapace lengths computed for the Greek samples were significantly greater than those for the Italian ones, a wide size range with superimposed modal components was found on both sides of the Ionian Sea. The estimated growth performance was the same in the two areas. In the Greek sampled population, the total mortality rates generally coincided with the natural mortality rates. No significant differences in the total mortality rates were detected between the Italian and Greek stock. The application of the yield per recruit model to the exploited stock, according to different scenarios, indicated conditions close to optimal harvesting. These results are discussed considering all the features which reduce vulnerability to fishing and favour recovery of the *A. antennatus* stock, thus blunting the differences in the population structure between the exploited and unexploited areas.

Keywords: *Aristeus antennatus*; Distribution; Maturity; Size structure; Population dynamics; Exploitation rate; Mediterranean Sea

1. Introduction

The blue-and-red shrimp *Aristeus antennatus* (Risso, 1816) represents one of the most important deep-water resources of the Mediterranean Sea,

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exploited by trawl fishing from the westernmost side throughout the basin as far as the western Ionian Sea (Bianchini and Ragonese, 1994). Considering the multispecies nature of Mediterranean fisheries, *A. antennatus* is caught together with many other species both by-catch and discards. According to the official Italian statistics (ISTAT), *A. antennatus* is landed together with other deep-water shrimps, mostly *Aristaeomorpha foliacea*, as the commercial category of "red shrimps". In the 1990s, the total Italian landings of "red shrimps" were between 3000 and 6000 t/year (Relini et al., 1999). Although their catches fluctuate largely according to the season and area, thousands of tonnes of "red shrimps" are landed along the Mediterranean coasts of the western and central basin (Fiorentino et al., 1998; Carbonell et al., 1999; Bas et al., 2003; Sardà et al., 2004).

The biology and ecology of *A. antennatus* have been much investigated in the last 20 years (Bianchini and Ragonese, 1994 and references therein; Cau et al., 2002 and references therein). However, several aspects of its population dynamics and exploitation condition remain vexed questions. Concerning population dynamics, the main uncertainties regard recruitment, for which very little information is available (Orsi Relini and Relini, 1988, 1998; D'Onghia et al., 1997; Mura et al., 1997; Sardà and Cartes, 1997), the growth parameter estimates, which are greatly affected by the size structure of the sampled population, and the mortality rate estimates, which are largely influenced both by growth parameter estimates and methods used (Orsi Relini and Relini, 1998). With regard to the exploitation condition, there are contrasting assessment results ranging from underexploitation to high overfishing for the different Mediterranean stocks (Fiorentino et al., 1998 and references therein). Indeed, in spite of the growth overfishing detected in most of the demersal Mediterranean resources (Caddy, 1993; Bombace, 1995), *A. antennatus* is probably the only highly exploited commercial species subject to a sustainable harvest rate (Demestre and Martin, 1993; Ragonese and Bianchini, 1996; Relini et al., 1999).

In the Ionian Sea (eastern–central Mediterranean) along the Italian coasts, where both *A. antennatus* and *A. foliacea* have long been intensively fished, the assessment carried out using analytical models indicated optimal exploitation of the former and overfishing of the latter (Matarrese et al., 1997). These authors found that *A. antennatus*, differently from *A. foliacea*, does not show the typical life-history effects of fishing (Jennings and Kaiser, 1998), such as the truncated size/age structure and the decrease in population reproductive potential. On the eastern side of the Ionian Sea along Greek coasts, where the commercial fishery is only carried out down to 400–500 m, recent studies on the population structure and dynamics of *A. antennatus* have detected various quite similar patterns between the study area, where the species is unexploited, and other Mediterranean areas where exploitation occurs (Papaconstantinou and Kapiris, 2001; Kapiris, 2004).

The very wide distribution of *A. antennatus* on bathyal bottoms (Sardà, 1993; Sardà et al., 1994, 2004) seems to play the main role in the recovery of the stock, thus indicating the importance of refuges for sustainable fishing (Gell and Roberts, 2003). However, its high fecundity, up to four times that of *A. foliacea* in the larger females (Orsi Relini and Semeria, 1983), should also be taken into account when considering the population resilience of this shrimp.

With the aim of providing a contribution to the debate regarding population dynamics and exploitation status of *A. antennatus* in the Mediterranean Sea, data collected during some study projects funded by EC and Italian and Greek governments were used. In particular, these data were taken using the same methodology and equipment for trawl fishing during the same periods in border-marker areas of the northern Ionian Sea with different fishing intensity: off the south-eastern Italian coast, where *A. antennatus* is exploited, and off north-western Greece, where there is no deep-water trawl fishing (unexploited area). The aim of this paper is the comparison of the population structure and dynamics of the blue-and-red shrimp between exploited and unexploited areas of the Ionian Sea.

2. Materials and methods

2.1. Areas of investigation

The Italian area is located along the Apulian coast of the north-western Ionian Sea and regards the Gallipoli fishery (Fig. 1). This fishery is mostly characterized by trawlers which exploit demersal resources from Monday to Friday only during day-light hours. The trawlers are smaller than 10 t of gross tonnage and