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Assessment of the *Aphia minuta* stock (Pisces: Gobiidae) by acoustic methods from the Bay of Alcudia (Mallorca, Western Mediterranean)

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SUMMARY: Acoustic techniques have been used for the first time to evaluate the abundance and distribution of the *Aphia minuta* stock (Pisces: Gobiidae) from the Island of Mallorca (Baleares, Spain). Acoustic surveys have been carried out during three consecutive seasons (1993, 1994 and 1995) in the more important fishing zone of this island, the Bay of Alcudia. Indices were obtained for abundance (m^3) of this goby at the beginning of the fishing season. The volume of *A. minuta* has decreased from 12,902,751 m^3 in January 1993 to 1,161,248 m^3 in January 1995. The catches obtained have gone from almost six tonnes in 1993 to be practically nil in 1995.

Key words: Aphia minuta, Gobiidae, Mallorca (Spain), acoustic assessment.

RESUMEN: EVALUACIÓN DEL STOCK DE *APHIA MINUTA* (PICES: GOBIIDAE) CON MÉTODOS ACÚSTICOS EN LA BAHÍA DE ALCUDIA. – Se han utilizado por vez primera técnicas acústicas para evaluar la abundancia y distribución del stock de *Aphia minuta* (Pisces: Gobiidae) de la isla de Mallorca (Baleares, España). Las campañas de evaluación acústica se han realizado durante tres temporadas consecutivas (1993, 1994 y 1995) en la zona de pesca más importante de esta isla, la bahía de Alcudia, obteniéndose índices de abundancia en volumen (m^3) de este góbido a principio de la temporada de pesca. El volumen de *A. minuta* ha descendido de 12.902.751 m^3 en enero de 1993 a 1.161.248 m^3 en enero de 1995. Las capturas obtenidas han pasado de casi seis toneladas en 1993 a ser prácticamente nulas en 1995.

Palabras clave: *Aphia minuta,* Gobiidae, Mallorca (España), evaluación acústica.

INTRODUCTION

The commercial small-scale fleet of the island of Mallorca (Baleares) carries out during the winter months, from December to March, a specific fishery directed at pelagic gobies (jonquillo), the object species being *Aphia minuta* (Risso,1810) and the accompanying species *Pseudaphia ferreri* (De Buén and Fage, 1908) and *Cristallogobius linearis* (Von Düben, 1845) (Iglesias and Martorell, 1992).

The fishery is directed at concentrations of gobies close to the sea bottom wich are easily detected by echosounders. Schools of *A. minuta* have the peculiarity when near a motorised vessel, to cluster together, without changing position. On the contrary, most other pelagic species generally undertake a vertical fleeing movement. This characteristic allows the use of acoustic methods to determine the situation and abundance of these schools in the fishing area.

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The fleet devoted to this fishery is composed of about thirty vessels whose characteristic technical measurements are a tonnage of 6 GRT, a power of 75 HP and a length of 8.5 metres. The catches of jonquillo during the last twelve years have oscillated between 79.5 tonnes in 1982/83 and 3.0 in 1994/95. The principal catches are obtained in the bays, the Bay of Alcudia being the area where the bulk of the fleet has been concentrated during the recent years.

Similar fisheries to that of Mallorca have developed in different zones of the Mediterranean Sea, such as the Spanish Mediterranean in the zone of Murcia (Martínez-Baños *et al*., 1993), and the Italian Mediterranean in the northern Tyrrhenian (Serena *et al*., 1990), the central Adriatic (Froglia and Gramitto, 1989) and the southern Adriatic (Ungaro *et al*., 1994).

The aim of this work was to assess the jonquillo stock from the Bay of Alcudia. This was the first time that acoustic techniques were used to estimate the abundance of an *A. minuta* stock. Acoustic surveys were carried out during three consecutive years (1993-95).

MATERIAL AND METHODS

The surveys were carried out at the beginning of January, when the schools of jonquillo appear in this area and the fishing effort exerted on the fishery is still moderate. The motor ship of 9.9 hp and 7 metres long was equipped with a 38 Khz paper echosounder (SKIPPER 815, SIMRAD), a ceramic transducer towed body (10 x 20; 11º beam width) and a GPS. The echosounder was calibrated to maintain the speed of the paper (22 mm/min) for all the surveys, using a constant scale.

The area considered was between Cape Pinar and Cape Farrutx, reaching up to 5 metres deep in the vicinity of the coast.The elementary distance sampling unit (EDSU) was considered as the nautical mile and the designed sampling grid consisted of nine systematic parallel transects with a distance between them of one nautical mile (Fig. 1).

In order to obtain estimates of absolute abundance for the stock by volume (m^3), taking advantage of the special characteristics of immobility of the schools of this species, the method used was echosounder-mapping (MacLennan and Simmonds, 1992). Schools of jonquillo were presupposed to have a cylindrical form with the diameter of its base

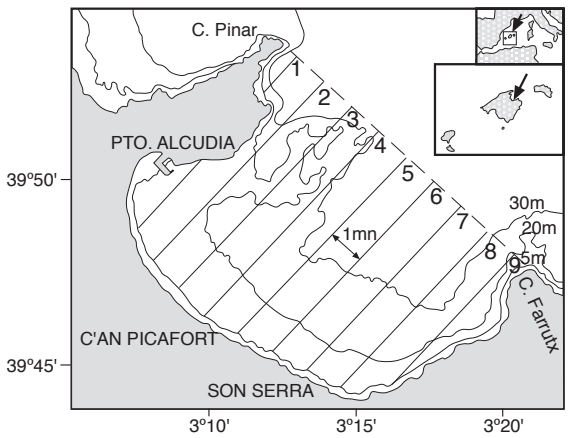

FIG. 1. – Bay of Alcudia (Mallorca): zone of acoustic assessment and sampling grid (9 transects).

the horizontal extension of the school on the echogram. The height and length of each cross-section were derived by correcting the observerd mark dimensions for the effect of beam width and pulse duration.

The identification of the jonquillo schools was carried out aboard the commercial boats by fishing the schools seen by the research vessel. During the course of the cruise and for the uncertain *A. minuta* registers, the location of the school was marked with a buoy and the boat passed repeatedly above it to confirm the identity of the goby.

Some basic criteria were established to decide which marks on the echograms were jonquillo schools, taking into account the form and position of the school on the bottom. In the first survey (January 1993), the reading was carried out by four groups, three of them set up by professionals of this fishery, and schools were considered as jonquillo only when all the groups agreed. In the following surveys, the echograms were read by two independent and experienced readers and only the coincident readings have been considered as valid.

Abundance maps were made with the total volume of jonquillo by mile (EDSU) for every year, in order to compare changes in the volumes and distribution of the resource by years.

RESULTS

The degree of coverage of the three acoustic surveys has always been the same, covering the nine transects of the sampling grid, with a total of 54 navigated miles and a mean work speed of 3.7 knots (nautical miles/hour).

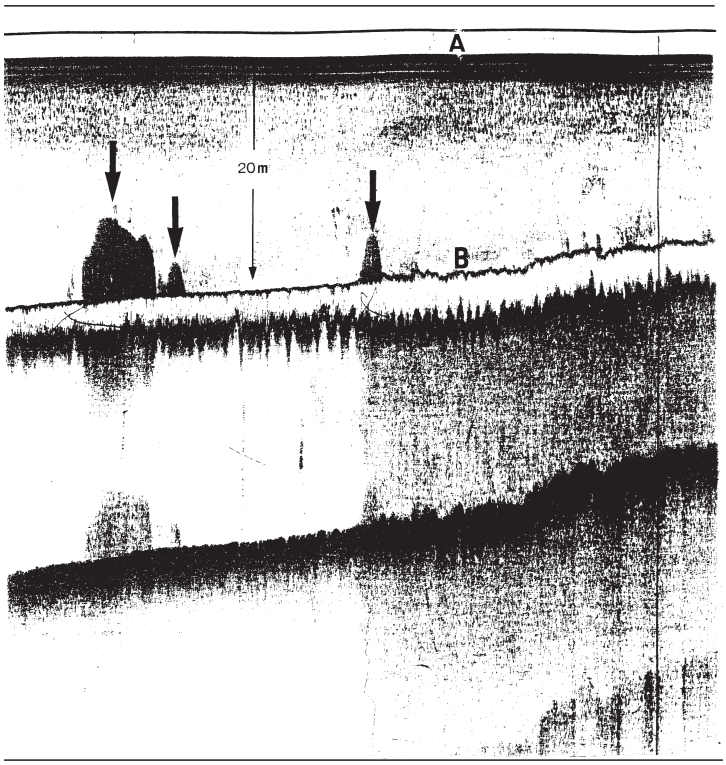

FIG. 2. – Echogram of jonquillo schools (arrows) at 20 m depth. (A) surface, (B) marine bottom.

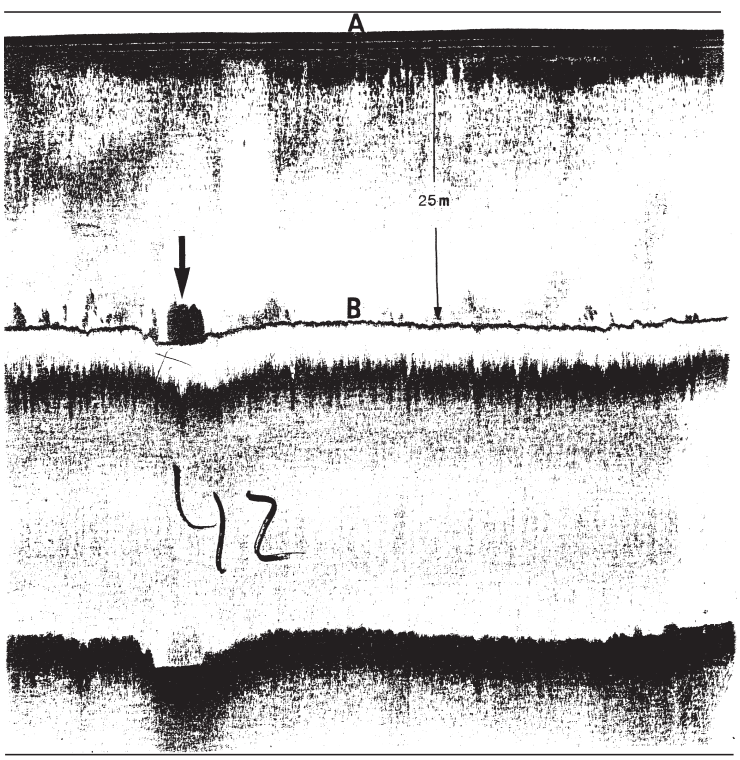

FIG. 3. – Echogram of a jonquillo school (arrow) at 25 m depth. (A) surface, (B) marine bottom.

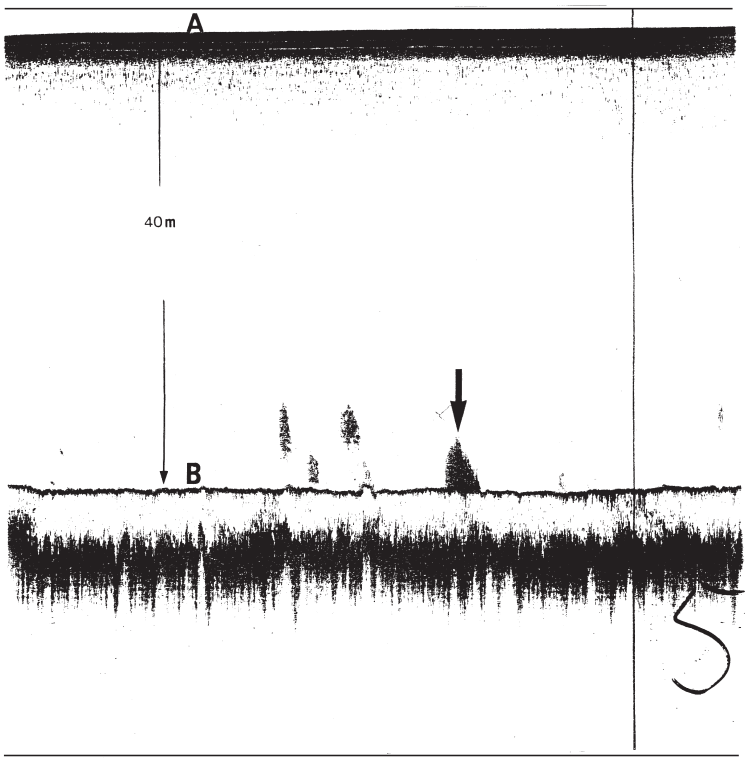

FIG. 4. – Echogram of a jonquillo school (arrow) at 40 m depth. (A) surface, (B) marine bottom.

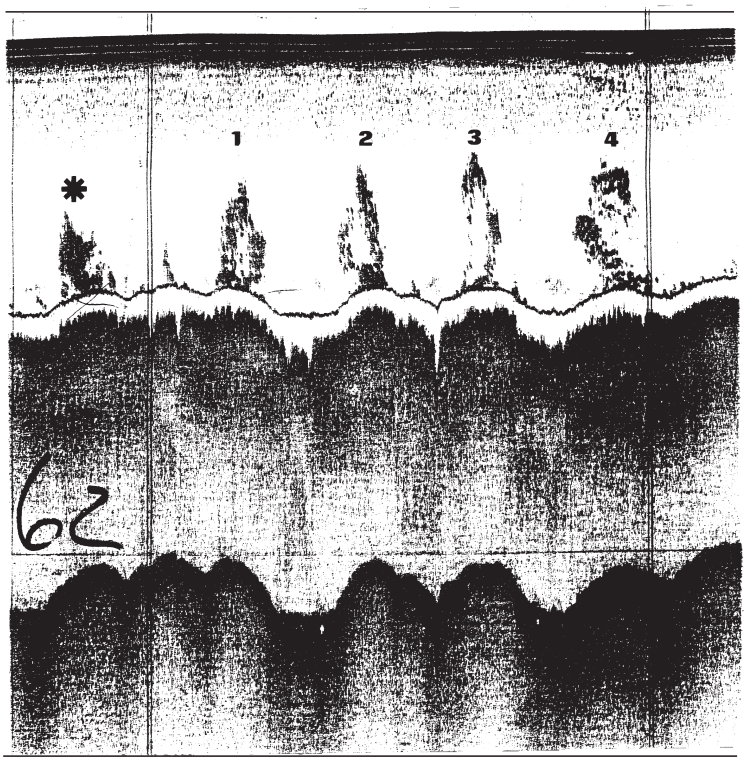

FIG. 5. – Echogram of the fleeing and scattering pattern of a pelagic school (*). The numbers 1 to 4 correspond to different passes of the boat above the school.

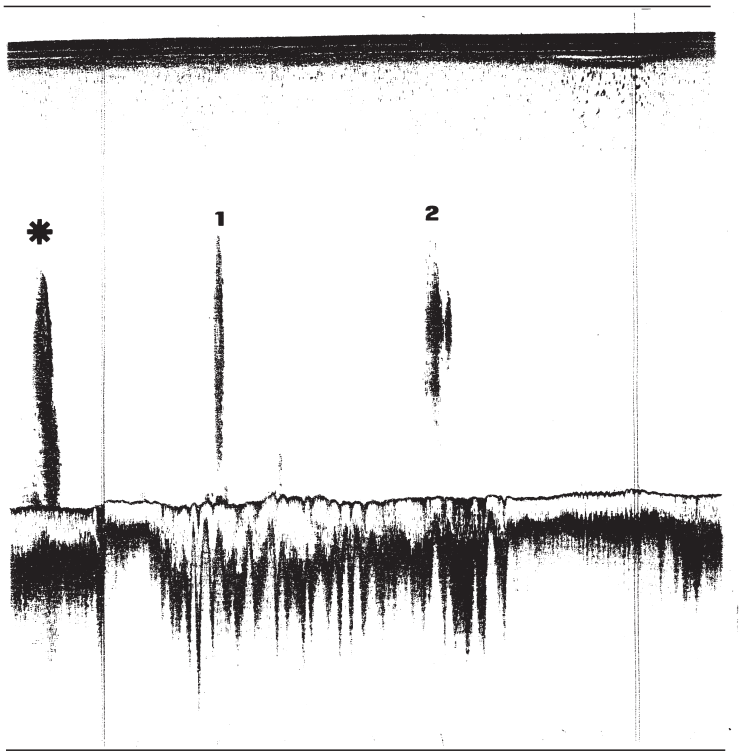

FIG. 6. – Echogram of the fleeing and scattering pattern of a pelagic school (*). The numbers 1 and 2 correspond to different passes of the boat above the school.

The schools of jonquillo have been identified easily on the echograms (Figs. 2,3,4). The schools were found close to the bottom during the day and did not move from the site where they were located. If a different pelagic species appeared, the school would disintegrate into a rising fleeing movement every time that a pass was made above it (Figs. 5 and 6).

The number of *A. minuta* schools detected during the surveys provided the first relative index of the abundance of fish in the area. During the first cruise (1993) a total of 223 possible schools of jonquillo were detected of which only 85 were considered as such, following the established criterion for the four groups of echogram readers that agreed. The coincidences in the reading of schools was 59% for two readers, 44% for three readers and 38% for four readers. The reading of the echograms in the following cruises did not give interpretation problems, detecting 30 schools in 1994 and 37 in 1995 (Table 1).

Since the size of the schools varied considerably, the estimate of the abundance of the resource improved on calculating the total volume of schools (Table 1). The volumes of the schools detected during the surveys took in a very wide range, the volume of the smallest school being 4 m^3 and the volume of the largest one 84077 m^3. On the first cruise (1993) the volumes of the schools detected were found between 13 and 84077 m^3, with an abundance of large schools, between 1000 and 10000 m^3 (45%) (Fig. 7). The depths to which they were located varied between 14 and 40 m, being more abundant (65%) between 30 and 40 metres. In 1994, the volumes of the schools were found between 17 and 10456 m^3, the size of the schools being smaller than

TABLE 1. – Number and volume (m^3) of jonquillo schools detected in the surveys; abundance indices; volume total estimated of jonquillo stock and catches of this goby obtained after surveying.

Year	Nº schools	Total volume (m^3)	Index (‰)	Total volume stock (m^3)	Catches (tons)
1993	85	351 976	3.00	12 902 751	6
1994	30	30 498	0.30	1 290 275	0.4
1995	37	15 849	0.27	1 161 248	-

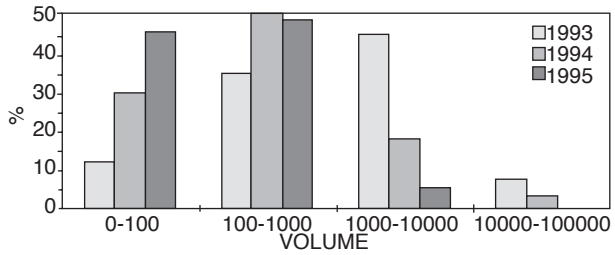

FIG. 7. – Distribution of the volumes (m^3) of the jonquillo schools by year.

the previous year, and the greatest abundance between 100 and 1000 m^3 (50%) (Fig. 7). The depth to which they were found varied between 7 and 33 metres. In 1995 the range of the volumes of the schools was found between 4 and 6756 m^3, with a greatest abundance between 100 and 1000 m^3 (49%) and an almost complete absence of large schools (Fig. 7). The depths to which they were found varied between 11 and 39 metres. Therefore, in addition to being scarcer the schools were smaller.

A relationship has not been found between the size of the school and the depth at which it was found, with schools of different volumes at all depths. Schools have not been found to depths greater than 40 metres, during this period of the year, therefore it seems that this isobath delimits the distribution area of this species in January. Schools have been detected on sand as well as on rock bottoms.

The volume of the schools included in the transducer beam allows us to find a relationship with the total volume of water surveyed during the cruise. For a total volume of water surveyed during the cruises (15.480.484 m^3), indices of abundance for each year were obtained. This extrapolates to the total volume of water from the Bay of Alcudia, providing the total volume of the jonquillo stock for each year (Table I).

Upon relating the volume estimated for each year with the *A. minuta* catches obtained from the stock, a relationship was observed. During the 1993 season the total volume of the evaluated stock was about 12 million m^3 and the catches obtained were 6 tonnes in this zone. For the 1994 season the estimated volume decreased, to around 1 million m^3 for this species and the catches obtained for the same dates suffered a strong decline with respect to the previous year, not reaching half a tonne. For the last season (1995) the catch data for the fleet are practically nil in this zone, due in part to the shortage of the resource, to the small size of the schools and to their position on rocky terrain inaccessible for the fishing gear.

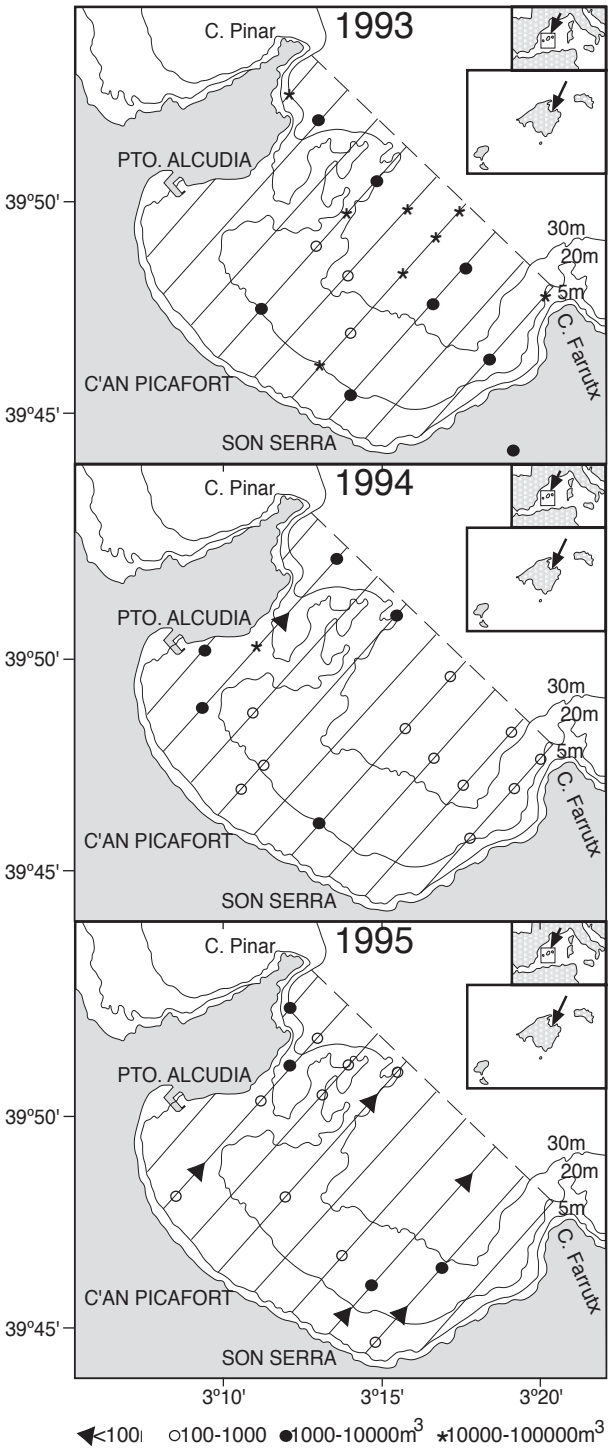

FIG. 8. – Distribution and abundance maps of jonquillo in the Bay of Alcudia in January 1993, 1994 and 1995.

The sum of the volume for jonquillo by navigated nautical mile has allowed us to carry out distribution maps of the resource for each year, that reflects the zones of greater abundance for this goby (Fig. 8 a,b,c).

DISCUSSION

The small-scale fishery of jonquillo in Mallorca is directed towards the goby *A. minuta* in its adult state The importance of this fishery is due to its great tradition in the island and to the fact that it occupies an important part of the commercial fleet during the winter months.

The environmental and fishing exploitation changes affect to a large extent this small sized pelagic neritic goby, with a life cycle of less than a year (Iglesias *et al*., 1997), since the recruitment of each season depends mainly on larval mortality and the fishing rate of the breeding stock of the previous season.

Consequently, it is all-important to know the abundance of the stock at the beginning of the fishing season, in order to compute which volume can be removed from it without damaging its continuity. Years of intensive fishing on the stock could give rise to years of scarcity, or could even finish the population as occurred in the southern Mediterranean Spanish zone (Málaga) in which an excessive extraction of "chanquete" (*A. minuta*) exhausted the fishery compelling the fleet to change its objective species to clupeiformes (*Sardina pilchardus* and *Engraulis encrasicholus*) (García *et al*., 1981).

The application of a direct assessment method of stocks based on acoustic techniques, has turned out to be the most adequate method to determine the abundance of the *A. minuta* stock. Furthermore, the fact that schools of this species are maintained in the zones in which they have been detected, practically without moving from the area, facilitates to a large extent the assessment of this resource.

The scientific echosounder equipment used at present (e.g. EK500; SIMRAD), which employs the echointegration systems (Forbes and Nakken, 1972), was not available for this study. Therefore, by adapting to the available equipment (paper echosounder), the assessment of this pelagic goby was carried out based on the method of echosounder-mapping (MacLennan and Simmonds, 1992).

By means of the assessment of this species followed during three seasons, covering the same zone and with the standardised method, the results obtained in the acoustic assessments have been able to be compared with the catches obtained by the small-scale fleet of the stock evaluated each year. The legislation of the fishery compels the catches of jonquillo obtained in Mallorca to be marketed through the central fish auction wharf in Palma, therefore a fairly rigorous control of the catches is carried out in each zone. This circumstance has given rise to reliable and exact data being obtained for the catches from the Bay of Alcudia, for each one of the studied years.

The results of the acoustic assessments carried out at the beginning of the fishing season in the Bay of Alcudia are consistent with the evolution of the catches obtained between the date on which the assessment was carried out and the end of the fishing season. These results have confirmed the reliability of the method and its usefulness, for determinig catch quotas for each season. Another application of this method is the location of new fishing grounds that could alleviate the fishing effort to which the currently fished zones of the bays are submitted.

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