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DISTRIBUTION OF FOUR CEPHALOPODA SPECIES ALONG THE CATALAN COAST (NW MEDITERRANEAN) USING GIS TECHNIQUES

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ABSTRACT: In this study the distribution of 4 Cephalopod species (*Loligo (Alloteuthis) media, Loligo vulgaris, Illex coindetii* and *Eledone cirrhosa*) along the Catalan coast (Northwest Mediterranean) was analysed. Data from experimental trawl catches from 1981 and 1991 were gathered for comparison purposes considering seasonal scale in terms of kg per hour. Both temporal and spatial scales were plotted in order to have a thorough analysis of species distribution pattern. Georeferenced biomass indices were extrapolated along the fishing area using the kriging technique in order to have an estimation of biomass by fishing grounds. During 1981 two species abundance (*Eledone cirrhosa and Loligo vulgaris*) were significantly higher with respect to 1991. *Loligo (Alloteuthis) media* and *Illex coindetii* maintained a similar level during both study periods. Some differences in seasonal distribution were found, for example, *Eledone cirrhosa* showed highest abundance during spring in both years along the northern area, decreasing to its lowest level during autumn. *Illex coindetii* showed its highest abundance in spring. Meanwhile abundance of *Loligo (Alloteuthis) media* was higher during summer along the central area and *Loligo vulgaris* showed a similar seasonal pattern along the southern area.

INTRODUCTION

Mangold and Boletzky (1988) mentioned fifty-nine cephalopod species in the Mediterranean; forty-seven of them have been collected off the Catalan coast (Sánchez *et al.,* 1998). The most abundant cephalopods in trawl catches are *Octopus vulgaris, Eledone cirrhosa, Loligo vulgaris*, and *Sepia officinalis* and, to a lesser extent *Loligo (Alloteuthis) media, Illex coindetii, Sepia orbignyana* and *Sepia elegans* (Sánchez, 1986; Sánchez and Martín, 1993).

In the present work we have implemented a GIS platform incorporating trawl haul data from experimental trawl hauls off the Catalan coastal waters, Northwestern Mediterranean Sea. The four most abundant Cephalopoda species (*Loligo (Alloteuthis) media, Loligo vulgaris, Illex coindetii* and *Eledone cirrhosa*) have been analysed along the Catalan shelf. Data from trawl catches from 1981 and 1991 were compared in order to know the interannual distribution of the species.

The application of GIS frameworks for marine biomass mapping is becoming a generalised tool for improved monitoring and management of exploited populations. Scattered georeferenced data that was once gathered for particular purposes, can be easily assembled into a major database and be plotted into one map. Besides being of use in the actual plotting of biomass distribution, GIS functionality can be applied to various statistical and resource modelling situations (Meaden, 1996).

MATERIAL AND METHOD

For the present study two data sets from scientific surveys, with 10 years difference, were analysed along the Catalan coast. Cephalopods hauls data from "AQUDE"(1) (1981–1982), and "ARRASTRILLO"(2) (1991) projects were used considering species and seasonal surveys in order to establish inter-seasonal and decadal spatial distribution variation. Experimental trawls gathered

from the AQUDE (1981) data set consisted of 28 samples for summer season (July, August and September), 24 during autumn (October, November and December), 18 for winter (January, February and March) and 24 during springtime (April, May and June). Meanwhile, for the ARRASTRILLO (1991) data set 14 samples were gathered during summer, 18 during autumn, 17 for winter season and 17 for springtime. Locations of each haul and total catch per kg for each sorted species were considered. A species' hourly yield index was calculated (total kg * hours) and used as a georeferenced biomass index.

Seasonal samples were treated following the methodology explained in Maynou *et al*. (1998); the experimental semiovariogram was calculated and employed as a descriptor of the spatial structure of each species biomass indices. The semiovariogram is a form of computing the variance of a population taking into account the spatial positions of all the samples. The variogram is used to determine the local neighbourhood of observations used while interpolating, and how the weights are applied to the observations during the calculation. The VARIOWIN software package (Pannatier, 1994) was used to generate variograms and helped to choose a variogram model, as it allows to select the model that best fits the experimental variogram computed from raw data.

For the purpose of mapping each resource, we employed the spatial estimation technique known as point kriging within boundaries defined by the presence of samples. In order to implement the kriging technique, the experimental semiovariograms parameters where seeded into the gridding process using the SURFER package (Golden Software, Inc).

(1) "AQUDE: Evolución de la degradación de comunidades explotadas; Análisis dinámico de los modelos multiespecíficos de las pesquerías del Mediterráneo." funded by Comisión Asesora de la Presidencia del Gobierno para la Investigación Científica y Técnica (CAICYT).
(2) "ARRASTRILLOS: Estudi de l'impacte de la pesca dels arrastrers petits en els stocks d'especies comercials en la costa catalana." Funded by Generalitat de Catalunya.

RESULTS

Figure 1 shows the distribution of *Loligo (Alloteuthis) media* during 1981–82 and 1991.

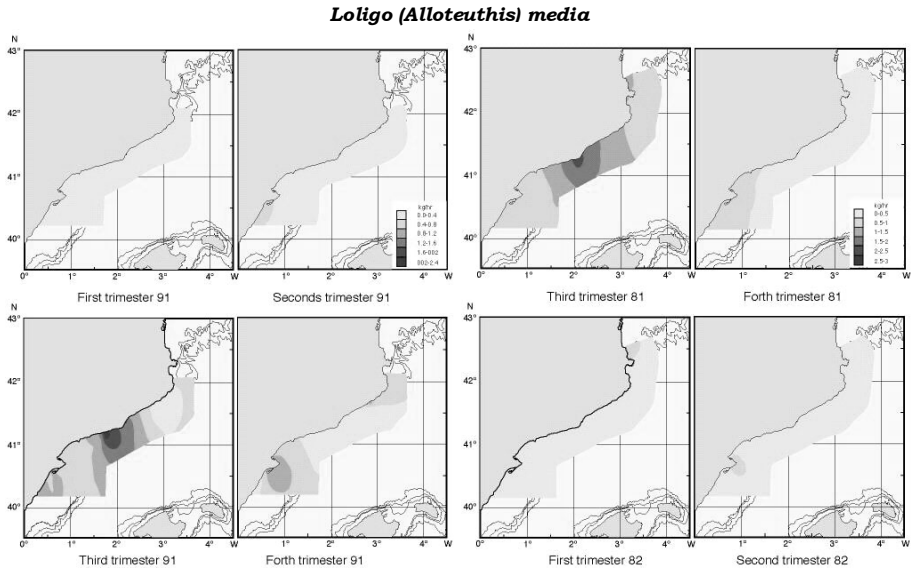

Figure 1. High-resolution density maps for *Loligo* (*Alloteuthis) media* . Magnitudes are expressed in kg per trawl hour.

The highest abundance occurs during the third trimester, summer (July–September) in both years, around the central region of the studied area. During the fourth trimester, autumn (October – December) the maximum abundance is observed around the southern area, associated to the Ebro's delta system. The overall abundance is very similar during the two studied years.

Analysis of size frequencies in catches was only available in 1991. More larger individuals were found in the third and fourth trimesters than in the second. (Fig 2).

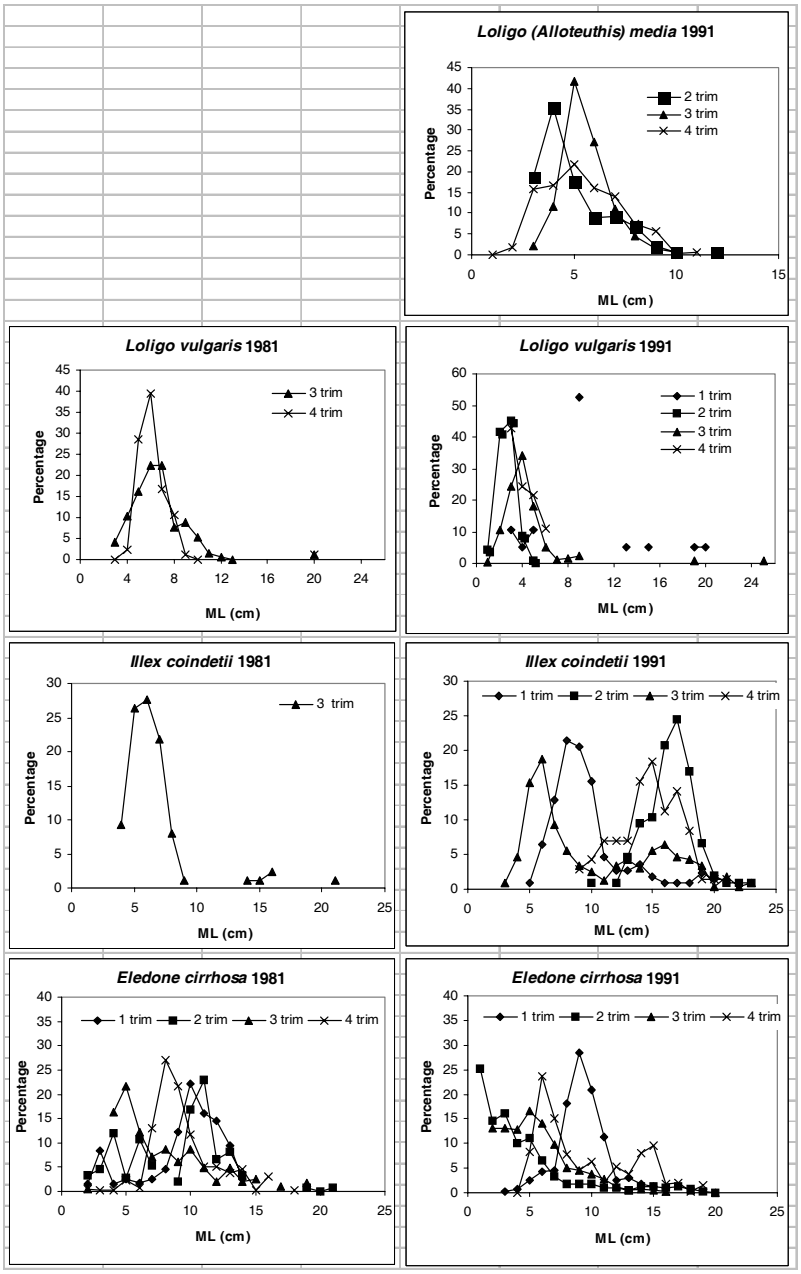

Figure 2. Quarterly size frequency distribution of *Loligo* (*Alloteuthis) media, Loligo vulgaris, Illex coindetii* and *Eledone cirrhosa* throughout the two years of the study.

Loligo vulgaris (Fig 3) also showed a marked seasonal pattern. The highest abundance occurred during the third trimester (summer), although this species' spatial distribution is different; while in 1981 the maximum concentration was around the southern area, in 1991 it was more widely spread , with high values in both the central and southern limits of the studied area. During other seasons, the spatial distribution of this species varied significantly in the two years studied.

The size frequency distribution (Fig 2) shows that individuals caught during the third trimester are mostly small and medium size.

For *Illex coindetii,* (Fig. 4), the maximum abundance was observed during the second trimesters of both periods studied. However, the geographical distribution changed as maximum values during 1981 were observed around the southern area, while in 1991 maximum concentrations occurred within the northern area.

The size frequency distribution for *I. coindetii* caught in 1991 showed that that most individuals were large, except the individuals captured in the third trimester of both years that were mainly small. In the case of *Eledone cirrhosa* the abundance distribution among different periods also showed a strong seasonal pattern, as in previous species, (Fig.5). Maximum abundance appeared during the second trimester (spring) in both studied periods. The species seems to be more associated with the northern area except in the second trimester of 1982 when the biggest concentration was in the southern area. In this species, the size frequency distribution for both years are quite different; in 1981 large individuals were caught during the second trimester, coincidentally with the annual maximum abundance period. In 1991, large individuals appeared mainly in the first and fourth trimester, while the sizes of the individuals captured in the second trimester correspond to juvenile sizes.

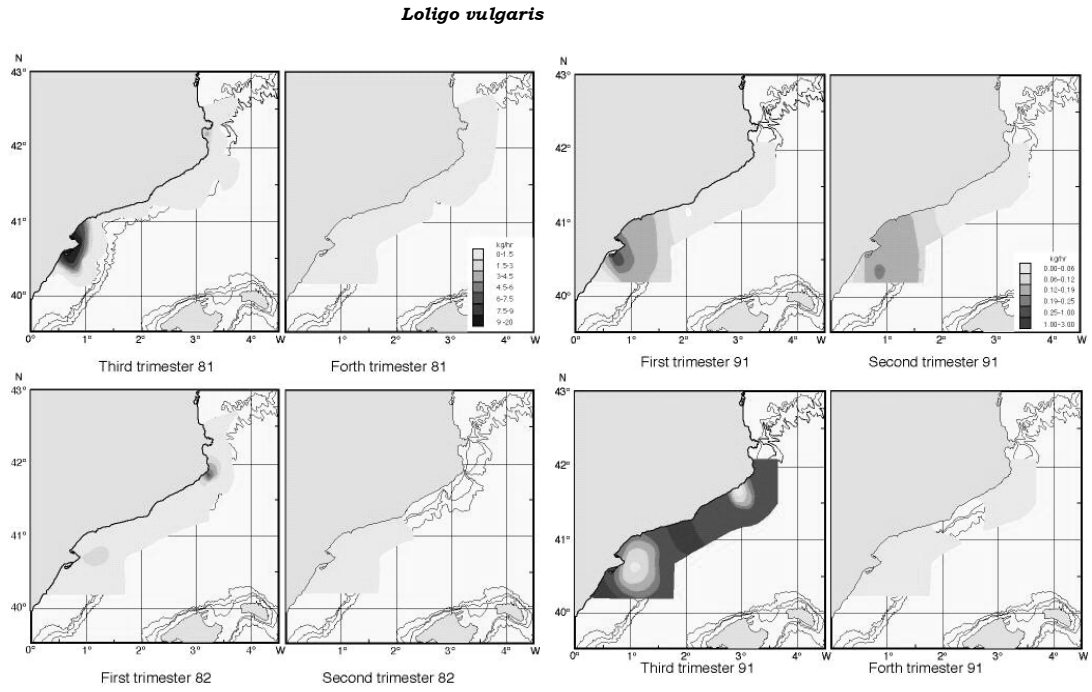

Figure 3. High-resolution density maps for *Loligo vulgaris*. Magnitudes are expressed in kg per trawl hour.

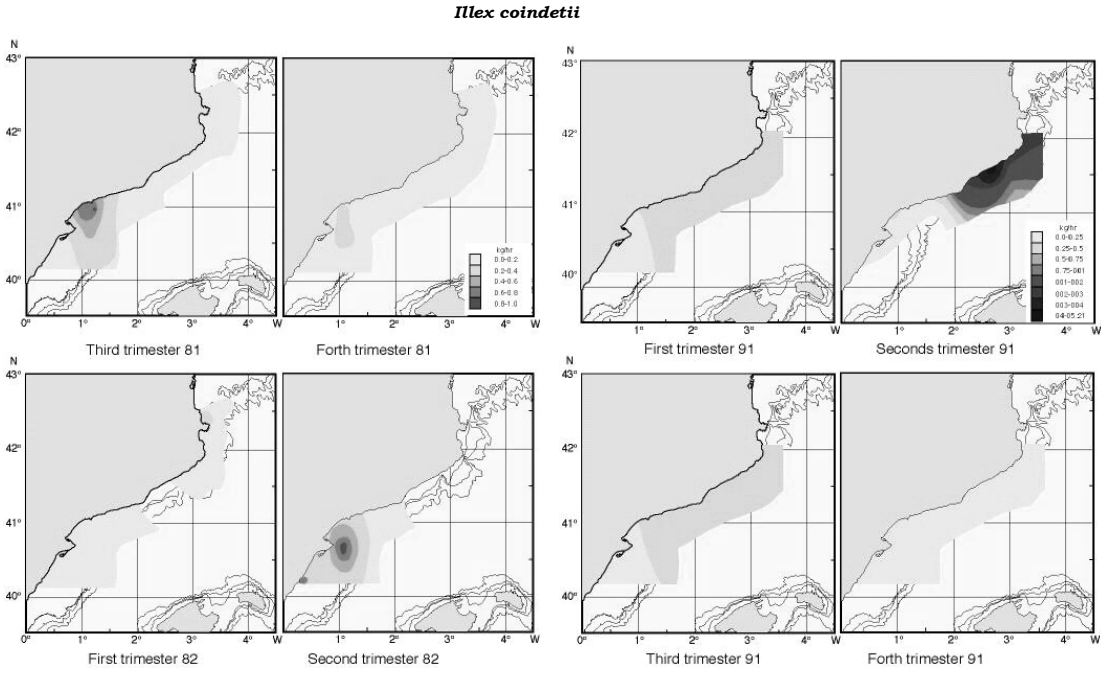

Figure 4. High-resolution density maps for *Illex coindetii*. Magnitudes are expressed in kg per trawl hour.

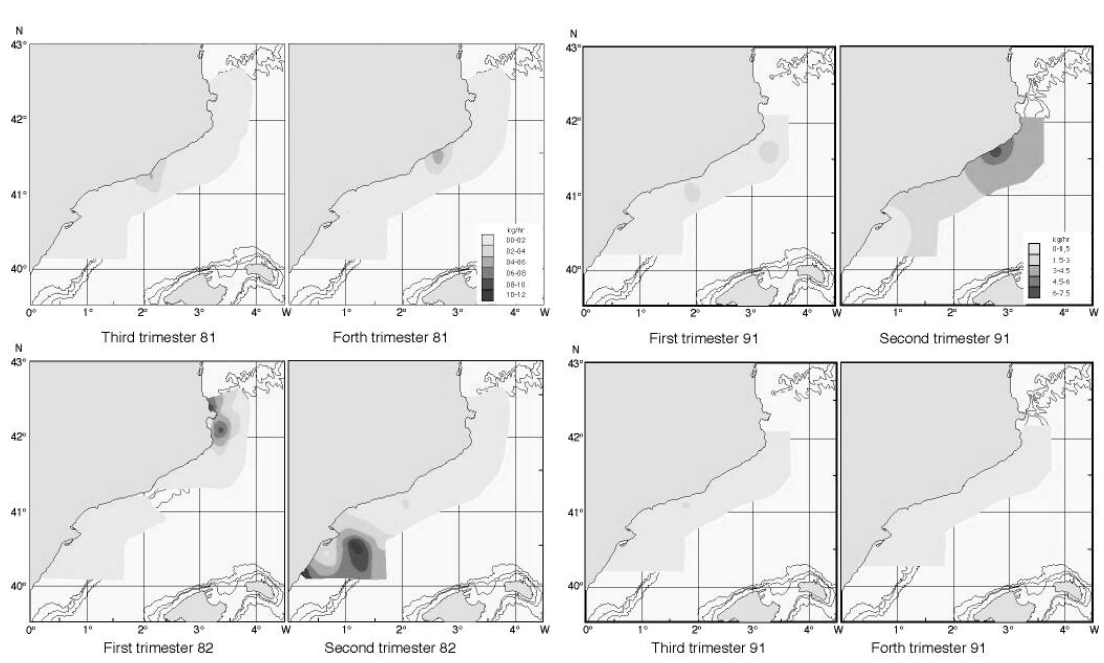

Figure 5. High-resolution density maps for *Eledone cirrhosa*. Magnitudes are expressed in kg per trawl hour.

DISCUSSION

In general terms, cephalopod catches show a strong seasonal pattern. *L. vulgaris* was more abundant in summer and autumn (Sanchez and Martin, 1993; Guerra *et al.*1994; Lloret and Lleonart, 2002).

Illex coindetii is mainly caught as a by-catch of fisheries operating in the Catalan coast. A large increase of the catches of this species has been observed since 1987 (Sanchez and Martin, 1993, Sanchez *et al*, 1998). *Illex coindetii* has a long spawning season which is stronger in autumn and spring (Sanchez *et al*, 1998). The highest maximum abundance values coincide with the reproduction seasons. The size frequencies confirm this hypothesis, although large individuals are caught during the whole year, their maximum concentrations occur in spring and autumn (2nd and 4th trimesters). Juvenile catches take place during winter and summer (1st and 3rd trimesters). The reproductive season of *Loligo (Alloteuthis) media* spans from March to October with its peak from May to July. The males mature at a size of 5 cm mantle length, while the females mature from 8 cm ML (Mangold-Wirz, 1963). In 1991, 86% of squid caught were > 5cm mantle length, suggesting that most were mature, particularly in the third trimester.Most *Loligo vulgaris* individuals captured were small, immature, specimens (smaller than 15 cm; considered to be the size at maturation (Sanchez and Guerra 1994)). The large individuals were captured mainly in winter, in agreements with the reproductive season (autumn–winter). That is to say the maximum abundance detected in the present study were immature individuals. The reproductive behaviour of the species that comes closer to the coast to carry out the egg-laying (Worms, 1983) would explain the almost total absence of mature individuals in the trawl captures.

All the species studied exhibit marked seasonality and seem to be influenced by environmental parameters, and *Eledone cirrhosa* is the one that shows this tendency to the greatest extent. Lloret *et al*. (2001) pointed out that a very important relationship exists among the Rhône run-off during the reproductive time of *E. cirrhosa* (March through July) with the increase of captures of small *E. cirrhosa* in the following months. The fact that in both periods of the study the biggest abundance was detected near to the influence of two rivers (Ebro in 1982 and Rhône and Muga in 1991) could be due to their influence.

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