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Cephalopod species collected in the upper continental slope off Alicante (Western Mediterranean)

Especies de cefalópodos capturadas en el talud superior de Alicante (Mediterráneo occidental)

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ABSTRACT

The cephalopod fauna collected in 24 hauls carried out in the upper continental slope off Alicante (Western Mediterranean) by commercial trawlers is analysed. Samples were taken at depths between 237 and 611 m from April 1998 to December 1999. Eighteen species in 8 families were captured. *Todarodes sagittatus, Todaropsis eblanae, Rossia macrosoma, Sepietta oweniana, Eledone cirrhosa* and *Octopus salutii* were the most abundant species. Cephalopods represented 3.9 % of the total catch (94 kg). Average cephalopod biomass estimated was 89.2 g/hectare. The known depth range for *Octopus defilippi* in the Mediterranean is expanded up to 370 m. Observed seasonal changes in biomass of main species are discussed.

RESUMEN

En el presente trabajo se analizan los cefalópodos capturados por arrastreros comerciales en 24 lances realizados en el talud superior de la provincia de Alicante (Mediterráneo occidental). Las muestras fueron tomadas entre los 237 y 611 m de profundidad, entre abril de 1998 y diciembre de 1999. Se capturaron 18 especies pertenecientes a 8 familias. *Todarodes sagittatus, Todaropsis eblanae, Rossia macrosoma, Sepietta oweniana, Eledone cirrhosa* y *Octopus salutii* fueron las mãs abundantes. Los cefalópodos representaron un 3,9 % de la captura total (94 kg.). La biomasa de cefalópodos media estimada fue de 89,2 gr./hectárea. El rango de profundidad conocido para *Octopus defilippi* en el Mediterráneo fue ampliado hasta los 370 metros. Se discuten los cambios estacionales de biomasa de las especies más importantes.

KEY WORDS: Cephalopods; Trawl fishery; Seasonality; By-catch; Western Mediterranean.
PALABRAS CLAVE: Cefalópodos, Pesquería de Arrastre, Estacionalidad, Pesca Acompañante, Mediterráneo occidental.

INTRODUCTION

An important trawling fishery is conducted in the upper continental slope off Alicante (Western Mediterranean). The main target species of this fishery are

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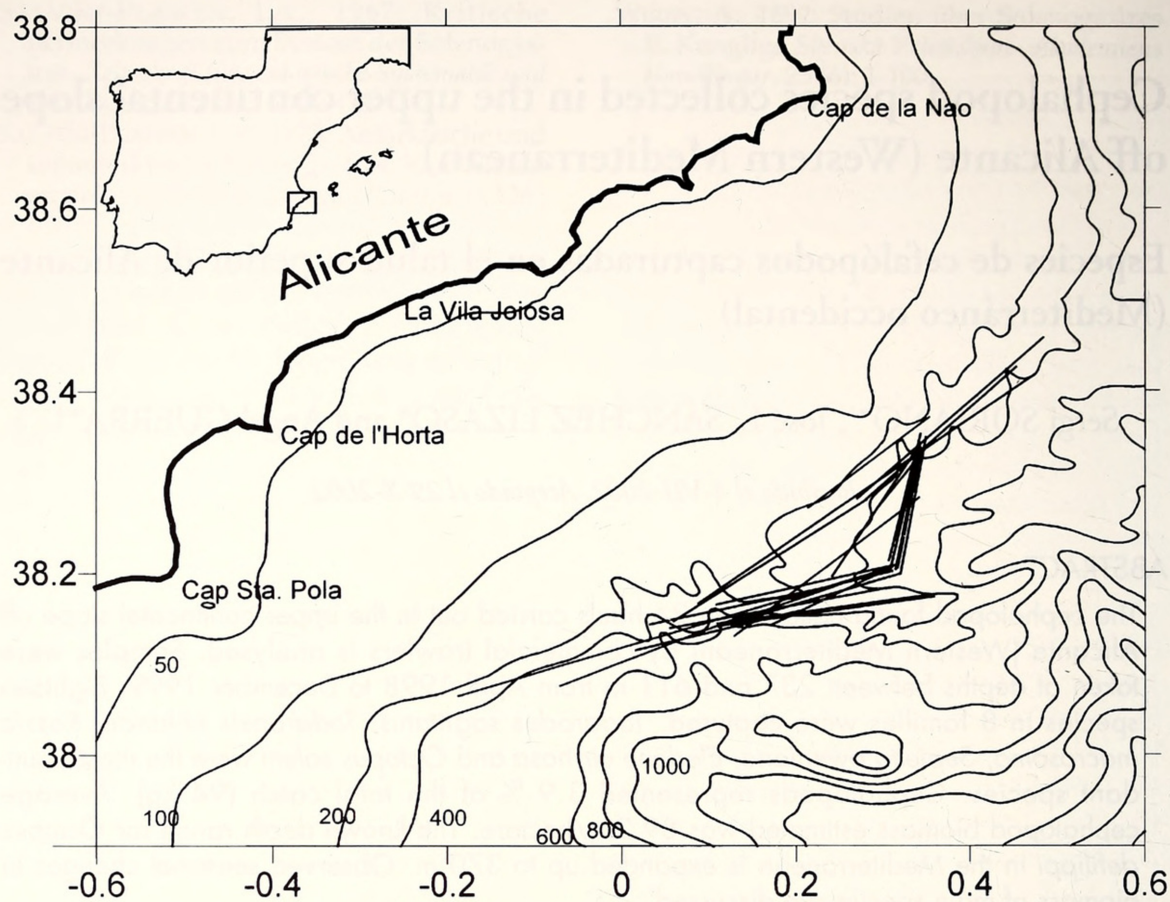

Figure 1. Location of samples in the study area. Lines link initial and final sampling positions.
Figura 1. Localización de las muestras en el área de estudio. Las líneas unen las posiciones iniciales y finales del muestreo.

Norway lobster (*Nephrops norvegicus*), rose shrimp (*Aristeus antennatus*), *Plesionika* spp., European hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*) and great fork-beard (*Phycis blennoides*). Cephalopods are not target species but contribute to by-catch (SORIANO, 2000).

Faunistic composition and spatial distribution of the cephalopods in the Spanish Mediterranean waters is relatively well known (see GUERRA, 1992 for a review). However, this information mainly corresponds to the Catalan Sea (41° N to 43° N). Thus, the results of cluster analysis in this area, as well as in the northern Tyrrhenian Sea, showed the presence of clear associations related with depth (SÁNCHEZ, BELCARI AND SARTOR, 1998). Cephalopod assemblages and some biological aspects of deep-sea cephalopods species were studied in the continental shelf and upper slope off Balearic Islands (QUETGLAS, ALEMANY AND SÁNCHEZ, 2000). On the other hand, different seasonal abundances were found in the bathymetric distribution of some species in the Catalan Sea that could be related to differences in the spawning and/or recruitment periods for each species (SÁNCHEZ, 1986; SÁNCHEZ *ET AL.*, 1998). Depth ranges recorded for 10 species from the bathyal basin (1000-2000 m depth) of the North-Western Mediterranean were analysed and discussed by VILLANUEVA (1992), who suggested an up-slope ontogenic migration of *Bathypolypus sponsalis* and *Neorossia caroli*. Furthermore, the distribution and abundance of bathyal sepiolids in this area has notably increased as stated by VILLANUEVA (1995).

The results obtained by SARTOR, BELCARI, CARBONELL, GONZÁLEZ, QUET-

Table I. Data summary on trawling operations
Tabla I. Resumen de los datos de las operaciones de pesca.

Haul	Date	Initial position	Final Position	Min Depth	Max Depth	Surface (km2)	Total catch (kg)	Ceph catch (kg)
1	14/04/1998	38-28-645N / 0-32-266E	38-11-052N / 0-13-704E	333	522	0.896	210.5	3.8
2	10/07/1998	38-18-942N / 0-20-236E	38-10-771N / 0-19-096E	433	444	0.285	69.5	6.3
3	10/07/1998	38-09-195N / 0-21-305E	38-07-122N / 0-06-325E	602	602	0.530	70.6	1.2
4	17/07/1998	38-18-942N / 0-20-236E	38-10-771N / 0-19-096E	433	444	0.285	41.7	1.9
5	17/07/1998	38-09-500N / 0-12-384E	38-10-761N / 0-17-889E	426	500	0.183	41.0	7.7
6	21/08/1998	38-19-349N / 0-20-432E	38-10-621N / 0-19-119E	444	444	0.285	96.3	1.2
7	21/08/1998	38-10-693N / 0-17-879E	38-07-177N / 0-10-024E	426	426	0.611	268.9	1.0
8	04/09/1998	38-19-830N / 0-20-375E	38-11-671N / 0-18-255E	407	463	0.346	177.2	4.2
9	04/09/1998	38-10-701N / 0-17-889E	38-07-524N / 0-07-347E	389	426	0.530	141.7	3.7
10	16/10/1998	38-02-764N / 0-04-881W	38-07-692N / 0-07-625E	611	611	0.407	38.4	1.1
11	16/10/1998	38-07-328N / 0-03-068E	38-11-094N / 0-15-578E	351	444	0.469	68.5	2.4
12	23/10/1998	38-19-262N / 0-20-377E	38-10-649N / 0-19-090E	407	433	0.318	57.6	1.8
13	23/10/1998	38-14-639N / 0-16-871E	38-18-838N / 0-20-721E	388	426	0.570	169.3	3.5
14	13/11/1998	38-05-303N / 0-00-374E	38-08-106N / 0-11-955E	574	611	0.367	16.7	0.7
15	13/11/1998	38-09-829N / 0-14-004E	38-07-143N / 0-01-413E	420	426	0.489	92.1	2.6
16	07/12/1998	38-10-701N / 0-17-889E	38-02-090N / 0-11-960W	444	454	0.937	89.2	4.2
17	12/03/1999	38-21-907N / 0-21-092E	38-15-411N / 0-12-516E	237	244	0.367	97.8	6.2
18	12/03/1999	38-16-044N / 0-15-958E	38-27-538N / 0-29-082E	366	377	0.652	170.8	7.3
19	18/03/1999	38-19-544N / 0-20-219E	38-10-594N / 0-14-243E	366	407	0.407	93.7	4.5
20	18/03/1999	38-15-978N / 0-16-526E	38-25-409N / 0-27-173E	352	370	0.566	132.9	4.4
21	23/04/1999	38-06-891N / 0-02-817E	38-09-785N / 0-18-263E	504	509	0.469	115.2	4.7
22	23/04/1999	38-10-535N / 0-18-540E	38-08-542N / 0-06-104E	426	444	0.530	85.9	3.9
23	04/06/1999	38-25-010N / 0-28-575E	38-08-627N / 0-04-798E	444	474	0.947	193.1	9.4
24	27/12/1999	38-19-693N / 0-20-497E	38-07-000N / 0-04-545W	426	370	0.926	473.8	6.1

GLAS AND SÁNCHEZ (1998) showed that few cephalopods are discarded from trawlers operating in the Western Mediterranean. Although discarding of cephalopod was practically negligible in terms of biomass in all-bathymetric strata analysed by the authors, in terms of number of species the discard component was, however, notable.

In Alicante and VALENCIA REGION, SÁNCHEZ AND OBARTI (1993) studied the biology and fishery of *Octopus vulgaris* and BLANCO, AZNAR AND RAGA (1995) analysed the cephalopod composition in the diet of the striped dolphin *Stenella coeruleoalba*. Despite this, little is known about the upper slope continental cephalopods from the Central Spanish Mediterranean Sea. Although GUERRA (1992) reported some species from this area, the cephalopod fauna of this region have not received especial attention. It is therefore important to determine what cephalopod species capture the trawling fishery operating off Alicante, which is one of the most important fishing areas of the Western Mediterranean (OLIVER, 1983). This paper provides a list of the cephalopod species caught during a project carried out with the objective of analysing the discards of the upper continental slope off Alicante, as well as some information on the bathymetric distribution and seasonal changes in the main cephalopod species abundance.

Table II. List of species collected in this paper after SWEENEY AND ROPER (1998).
Tabla II. Lista de especies obtenidas en el presente estudio según SWEENEY Y ROPER (1998).

Class *Cephalopoda* Schneider, 1784
- Order *Sepiida* Zittel, 1895
  - Family *Sepiidae* Keferstein, 1866
    - *Rhombosepion orbignyana* (Férussac, 1826)
- Order *Sepiolida* Grimpe, 1921
  - Family *Sepiolidae* Leach, 1817
    - Subfamily *Rossinae* Appellöf, 1898
      - *Rossia macrosoma* (Delle Chiaje, 1830)
      - *Neorossia caroli* (Joubin, 1902)
    - Subfamily *Sepiolinae* Appellöf, 1898
      - *Sepietta oweniana* (Orbigny, 1840)
- Order *Teuthida* Naef, 1916
  - Family *Loliginidae* Lesueur, 1821
    - *Loligo media* (Linnaeus, 1758)
  - Family *Enoploteuthidae* Pfeffer, 1900
    - *Abralia veranyi* (Rüppell, 1844)
  - Family *Onychoteuthidae* Gray, 1849
    - *Onychoteuthis* sp.
  - Family *Histioteuthidae* Verill, 1881
    - *Histioteuthis bonnellii* (Férussac, 1834)
    - *Histioteuthis reversa* (Verrill, 1880)
  - Family *Ommastrephidae* Steenstrup, 1857
    - Subfamily *Illicinae* Posselt, 1891
      - *Illex coindetii* (Vérany, 1839)
    - Subfamily *Todarodinae* Adam, 1960
      - *Todaropsis eblanae* (Ball, 1841)
      - *Todarodes sagittatus* (Lamarck, 1798)
- Order *Octopoda* Leach, 1818
  - Family *Octopodidae* Orbigny, 1840
    - Subfamily *Octopodinae* Grimpe, 1921
      - *Octopus salutii* Vérany, 1836
      - *Octopus defilippi* Vérany, 1851
      - *Scaeurgus unicirrhus* (Delle Chiaje, 1840)
      - *Pteroctopus tetracirrhus* (Delle Chiaje, 1830)
    - Subfamily *Eledonidae* Grimpe, 1921
      - *Eledone cirrhosa* (Lamarck, 1798)
    - Subfamily *Bathypolypodinae* Robson, 1928
      - *Bathypolypus sponsalis* (Fischer and Fischer, 1892)

MATERIAL AND METHODS

During the April 1998-December 1999 period, twenty four individual samples were collected on board two commercial trawlers at a number of sampling locations at the same fishing ground on the upper continental slope off Alicante. The studied area is situated between 38° 13′ N//0° 32′ E and 37° 54′ N//0° 6′ W (Fig. 1). Initial and final tow position, tow duration and initial and final depths were registered on board. Depth range varied between 237 and 611 m. Hauls were carried out during daytime. Mean tow duration was 4.2 h and towing speed was 2.5 knots. Effective

Table III. Mean abundances (± SE) expressed in g/hectare and ocurrences (in %) of the species of cephalopods caught.
Tabla III. Abundacias medias (± ES) expresado en g/hectárea y ocurrencias (en %) de las especies de cefalópodos capturadas.

SPECIES	Abundance (* SE)	Ocurrence
Rhombosepion orbignyana	0.40 * 0.34	8.70
Rossia macrosoma	9.18 * 2.55	69.57
Neorossia caroli	0.14 * 0.14	4,.35
Sepietta oweniana	4.00 * 1.24	73.91
Loligo media	0.09 * 0.07	13.04
Abralia veranyi	0.03 * 0.02	17.39
Onychoteuthidae	0.01 * 0.01	4.35
Histioteuthis bonnellii	1.39 * 1.39	4.35
Histioteuthis reversa	0.74 * 0.51	13.04
Illex coindetii	2.87 * 1.51	21.74
Todaropsis eblanae	6.63 * 2.31	47.83
Todarodes sagittatus	30.06 * 4.90	86.96
Octopus salutii	5.97 * 2.27	52.17
Octopus defilippi	0.45 * 0.45	4.35
Scaergus unicirrhus	0.80 * 0.80	4.35
Pteroctopus tetracirrhus	1.02 * 0.49	21.74
Eledone cirrhosa	25.19 * 16.37	26.09
Bathypolypus sponsalis	0.26 * 0.20	8.70

gear opening width was 22 m. The surface sampled during each tow was estimated using tow duration, towing speed and gear opening.

Commercial individuals were identified and weighed on board using a dynamometer. A random subsample of the discarded fraction of the total catch in each haul was taken. These subsamples were transported fresh to the laboratory. Cephalopod individuals in these subsamples were sorted, identified and weighed to the nearest 0.1 g and the results were extrapolated to the total amount of discards. Then, the individuals were fixed in 10% formaline and preserved in 70% alcohol. Finally, the abundance of each cephalopod species was estimated and expressed as grams per hectare.

RESULTS

Table I shows a summary of information on trawling operations. A total of 93.7 kg of cephalopods were captured. Cephalopods represented 3.86% in weight of the total catch. The mean biomass of cephalopod estimated was 89.2 g/hectare.

The cephalopods collected comprised 18 species in 8 families (Table II). One individual of the family *Onychoteuthidae* was caught but its stage of conservation did not allowed precise identification. Female *Argonauta argo* empty shells were caught. However, they have not been considered due to the lack of animal and the fact that currents can drift the empty shells.

Table III shows the mean abundance and percentage of occurrence of the species of cephalopod collected in the present study. *Todarodes sagittatus* was the most abundant species followed by *Eledone cirrhosa* and *Rossia macrosoma*. These three species together constituted 72.75% of the total cephalopods abundance. *Octopus salutii*, *Todaropsis eblanae* and *Sepietta oweniana* were very frequent

Table IV. Depth ranges of the collected species off Alicante and in other areas.
Tabla IV. Rango de profundidades de las especies capturadas en Alicante y en otras zonas.

Species	Depth range (m)	Source	Location
Rhombosepion orbignyana	40-460	Sánchez, 1986	Mediterranean
Rossia macrosoma	125-450	Sánchez, 1986	"
Neorossia caroli	150-1744	Sánchez, 1986; Villanueva, 1992	"
Sepietta oweniana	22-974	Lumare, 1970; Villanueva, 1992	"
Loligo media	0-200	Sánchez, 1986	"
Abralia veranyi			
Onychoteuthidae			
Histioteuthis bonellii	220-430	Sánchez, 1986	"
Histioteuthis reversa	0-1766	Joubin, 1900; Villanueva, 1992	"
Illex coindetii	50-280	Sánchez, 1986	"
Todaropsis eblanae			
Todarodes sagittatus	20-1000	Mangold-Wirz, 1963	"
Octopus salutii	30-800	Sánchez, 1986	"
Octopus defilippi	6-60	Wirz, 1958	"
Scaeurgus unicirrhus	235-700	Sánchez, 1986	"
Pteroctopus tetracirrhus	110-570	Sánchez, 1986	"
Eledone cirrhosa	10-570	Sánchez, 1986	"
Bathypolypus sponsalis	120-1835	Mannini, 1989; Villanueva, 1992	"

in the hauls but they were not abundant in terms of biomass. Finally, 10 of the 18 species were caught in less than 20% of the hauls and none of them achieved abundances greater than 2 g/hectare.

The highest cephalopod catches occurred in summer and winter. *S. oweniana*, *T. eblanae* and *O. salutii* showed their highest abundances in winter, while *E. cirrhosa* showed a peak in summer and *T. sagittatus* a decreasing pattern from summer to spring. *R. macrosoma* achieved its highest abundance both in summer and winter (Fig. 2).

Table IV shows the depth ranges for the eighteen species collected in the present study, together with the known maximum and minimum depths recorded for the same species in the Mediterranean and in other areas.

DISCUSSION

Faunistical composition of the present study is similar to other studies carried out in the Western Mediterranean (SÁNCHEZ, 1986; SÁNCHEZ *ET AL.*, 1998; QUETGLAS *ET AL.*, 2000) and Gulf of Cádiz (GUERRA, 1982) for the same bathymetric stratum.

Depth ranges of the species caught in the sampling were similar to those shown in SÁNCHEZ (1986), GUERRA (1992) and QUETGLAS *ET AL.* (2000). Despite these similiarities, an individual of *Octopus defilippi* was caught in a trawl between 366 and 377 m depth. This species is rare in the Iberian peninsula coasts and its bathymetric distribution is between 6 and 60 m depth in the Mediterranean (GUERRA, 1992). Nevertheless, it has been caught until 350 m depth in the Southern Coast of Portugal (REIS, CABIDO AND LEAL, 1984). Consistently, the bathymetric distribution range of this species in the Mediterranean should be extended. However, it was caught only once, so more data will be needed in order to confirm this fact. On the other hand, individuals of the squid *Loligo media* have been caught between 237 and 426 m depth, when the

Table IV. Continuation.
Tabla IV. Continuación

Depth range (m)	Source	Location	Depth range (m)	Source
			237-377	Present study
32-600	Mangold-Wirz, 1963	NE Atlantic	237-509	"
367-1332	Chun, 1913; Joubin, 1924	NW Atlantic	426-500	"
29-475	Bas *et al.*, 1976: Guerra, 1982	NE Atlantic	237-611	"
			237-426	"
			352-426	"
			366-377	"
70-2000	Mangold-Wirz, 1963	?	333-522	"
0-1332	Lu and Roper, 1979; Joubin, 1924	NW Atlantic	351-611	"
48-500	Mangold-Wirz, 1963	SW Atlantic	352-611	"
85- 660	Mangold-Wirz, 1963	SW Atlantic	237-509	"
0-1000	Clarke, 1966	NE Atlantic	351-611	"
			237-237	"
<350	Reis et al, 1984	NE Atlantic	366-377	"
70-430	Mangold-Wirz, 1963	Caribean Sea	237-244	"
70-680	Mangold-Wirz, 1963	Caribean Sea	352-509	"
10-770	Mangold-Wirz, 1963	NE Atlantic	366-500	"
358-930	Pérez-Gándaras and Guerra, 1978; Fischer and Joubin, 1906	NE Atlantic	400-444	"

known bathymetric distribution range of this species extends between the surface until 350 m depth (GUERRA, 1992).

Cephalopods represent a commercially important resource in Western Mediterranean but, deeper than 350 m, cephalopod catch rates are low and the majority of species have little or no commercial value (SARTOR *ET AL.*, 1998). In the Alicante upper slope fishery they contributed more to the discards (4.5%) than to the commercial catch (3.5%), being fishes and crustaceans the most important groups (SORIANO, 2000). The most abundant cephalopod species in this study were the squids *T. sagittatus* and *T. eblanae*, the octopuses *E. cirrhosa* and *O. salutii* and the sepiolids *R. macrosoma* and *S. oweniana*. The relatively high biomass of octopuses found in the trawl hauls may be explained by the benthic way of life of these animals, which increases the catchability of these species by the trawl gear. Moreover, the agreggational behaviour of squids (GUERRA, 1992) and sepiolids (VILLANUEVA, 1995) may explain the relatively high abundances of these groups in the catch.

Many authors studied changes in size distribution (i.e. VILLANUEVA, 1992; QUETGLAS, ALEMANY, CARBONELL, MERELLA AND SÁNCHEZ, 1998a), abundance (i.e. SÁNCHEZ, 1986; VILLANUEVA, 1995), biomass (i.e. SARTOR *ET AL.*, 1998; QUETGLAS *ET AL.*, 2000), reproductive parameters (i.e. QUETGLAS *ET AL.*, 1998a) and ecological parameters (i.e. QUETGLAS *ET AL.*, 2000) along the bathymetric gradient of cephalopods in the Western Mediterranean. To our knowledge, SÁNCHEZ (1986), QUETGLAS, ALEMANY, CARBONELL, MERELLA AND SÁNCHEZ (1998b), SÁNCHEZ *ET AL.* (1998) and SÁNCHEZ AND MARTÍN (1993) studied changes in cephalopods abundance according with season in this area. Nevertheless, they were not focused on deep-sea species. In this sense, information about biomass seasonal patterns of target and non-target species and the explanation of these patterns could be

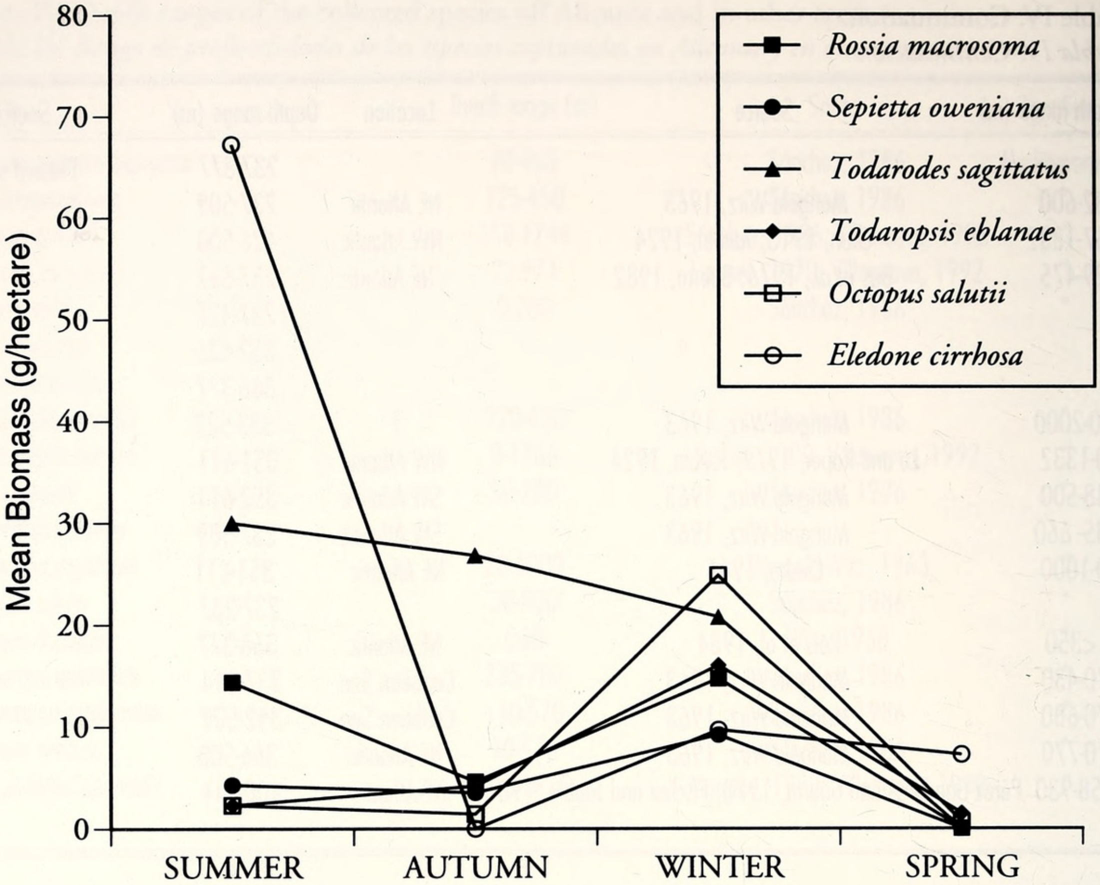

Figure 2. Seasonal abundances (in g/hectare).
Figura 2. Abundancias estacionales (en g/hectárea).

useful to understand the complex ecological relationships in the Western Mediterranean deep-sea and, in consequence, it may provide data for a better management of the fishery.

Seasonal changes of biomass observed in this study may be related with species life history (spawning and/or recruitment). *R. macrosoma* was caught in summer, autumn and winter, showing two peaks of abundance (summer and winter), being spring and autumn the spawning periods for this species in Western Mediterranean (GUERRA, 1992). In the present study no individuals of *R. macrosoma* were caught in spring, which agrees with observations by VILLANUEVA (1995). In the same way, *S. oweniana* spawns from March to November between 10 and 45 m depth (GUERRA, 1992), and its highest abundance level was observed in winter. It seems reasonable to think that both species may carry out reproductive migrations to depths out of present study sampling area.

The relatively high catch rates of *T. sagittatus* found in summer and autumn could be explained arguing that the spawning period of this species extends through these seasons, as observed in the Balearic Sea (QUETGLAS *ET AL.*, 1998a). On the other hand, the high catch rate could be also due to the fact that individuals are more concentrated during this period and, therefore, its catchability by the trawl gear increases. The decreasing trend in biomass from summer to spring could be related with changes in the intensity of spawning during the year, linked with a process of desaggregation after the spawning and due to a gradual ontogenic migration to deeper waters than local trawl fleet operation depths. In this sense, could be made a hypothesis about the existence of a variable spawning depth according to season, in which, individuals would spawn in shallow waters in summer while it would perform an increasing in the spawning depth until winter, when spawning period finishes for this species.

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