Coastal meroplanktonic larval stages of peninsula de Llevant natural reserve determined with light traps

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The microscale spatial distribution of coastal zooplankton was studied during the month of June at the largest marine reserve of Mallorca: Peninsula de Llevant using light traps. The assemblage was characterized by the most abundant taxa being peracarida crustaceans, including isopods, cumaceans and amphipods. Decapoda larvae, especially brachyuran megalopa larvae, were also abundant with *Monodaeus couchii*, *Pinnotheres* sp., *Ebalia* sp. and specimens from Portunidae family as the most abundant species. Analyses of crustacean abundance between light traps indicated a vertical distribution on the water column, with lower abundance at surface traps and higher at bottom traps. No clear horizontal pattern in total crustacean abundance was found, except in megalopa larvae that showed a gradient in relation to the distance to coastline. Light traps have been corroborated as a valuable tool for sampling crustacean larvae and therefore to assess effects of protection on planktonic stages.
Keywords: *larval stages, crustaceans, distribution, light traps, marine protected areas, Balearic Sea.*

DETERMINACIÓ DELS ESTADIS LARVARIS DEL MEROPLANCTON COSTANER DE LA RESERVA MARINA DE LA PENÍNSULA DE LLEVANT AMB TRAMPES DE LLUM. Es va estudiar la distribució a micro-escala del zooplancton costaner de la major reserva marina de Mallorca: la Península de Llevant mitjançant l'ús de trampes de llum durant el mes de juny de 2009. La comunitat es caracteritza per una gran abundància de crustacis peracàrids, incloent isòpodes, cumacis i amfípodes. Les larves de decàpodes, especialment megalopes de braquiürs van ser abundants, amb *Monodaeus couchii*, espècies dels gèneres *Pinnotheres* i *Ebalia*, i espècies de la família dels portúnids com les més comunes. L'anàlisi d'abundància de crustacis en funció de les trampes de llum indica un patró de distribució vertical, amb abundàncies baixes a trampes superficials i altes a trampes profundes. No es va tobar un clar patró horitzontal, amb excepció de les larves megalopa que presentaven un gradient en relació a la distància de la línia de la costa. Les trampes de llum han demostrat ser una eina valuosa pel mostreig de larves de crustacis i per tant per avaluar els efectes de la protecció en les etapes planctòniques.
Paraules clau: *estadis larvaris, crustacis, distribució, trampes de llum, àrees marines protegides, mar Balear.*

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Introduction

Marine communities are characterized by taxa having a wide range of reproductive patterns, ranging from species with direct development to species with larval stages spending a period of time in the plankton, from days to months, and estimated larval dispersal distances ranging from less than 1m to up to 4400km (Shanks *et al.,* 2003). Decapod larvae constitute an important part of the coastal zooplankton and play an important role on fish larval feeding. They undergo several pelagic larval stages, which varies from species to species, a primary zoea stages and a megalopa post-larval stage which is the transition between the planktonic larval phase and the benthic juvenile stage responsible for settlement (Abelló *et al.,* 1999). Unfortunately, larval stages and larval dispersal distances are known for only few species.

Several studies on coastal zooplankton assemblages' composition and distribution patterns have been conducted in recent years on the Mediterranean Sea and the Atlantic Ocean (González-Gordillo *et al.,* 2003). Balearic Sea has been the centre of several studies on zooplankton distribution (Fernández de Puelles *et al.,* 2003, 2004) at mesoscale levels, but there is a lack of knowledge at small spatial scales. Because of the potential dispersal role of larval stages, vertical distribution can be of particular importance to meroplanktonic larvae of benthic marine invertebrates. Most species with a planktonic larval phase in their life cycle undergo vertical migration. The phenomenon has been widely studied (Zaret *et al.,* 1976; Hays, 2003).

In most cases, vertical migration is related to lunar cycles or environmental changes, such as light cycles, in which plankton move towards light in response to decreasing light intensity, away from light in response to increasing light intensity and disperse at constant light intensity (Tranter *et al.,* 1981). Hence, while many larval and juvenile stages of marine organisms are attracted to light (Deudero, 2002), factors such as temperature, pressure, salinity and current, can also affect vertical migration and larval behaviour (Forward, 1990).

Plankton nets have been largely used to collect larvae in studies of temporal and spatial patterns of crustacean larval distribution (Abelló *et al.,* 1999; Landeira *et al.,* 2009). Comparative studies of fishes using passive collecting methods, as plankton nets, often underestimate the abundance of taxa and larval stages with strong ability to swim in comparison with active aggregation methods, like light traps (Choat *el al.,* 1993). The traps, originally designed by Doherty (1987) have been extensively used and modified to suit in different ambients and studies (Meekan *et al.,* 2001; Hovda *et al.,* 2003). Because light traps have the potential to trap positive phototactic mobile zooplankton they can be considered as a good device for sampling marine invertebrates (Granek *et al.,* 2007).

In the present study, we investigated the spatial and vertical distribution of the nearshore meroplanktonic assemblages in the Peninsula de Llevant Marine Natural Reserve by applying to a passive collection method of using light traps. Marine protected areas (MPAs) have become a popular management tool in the Mediterranean Sea for preserving biodiversity or increasing fisheries yields (Palumbi, 2003). Moreover, the design and size of MPAs play an important role in the sustainability of protected populations, communities and ecosystems, but it requires understanding the larval import and export dynamics in order to improve marine protected areas management.

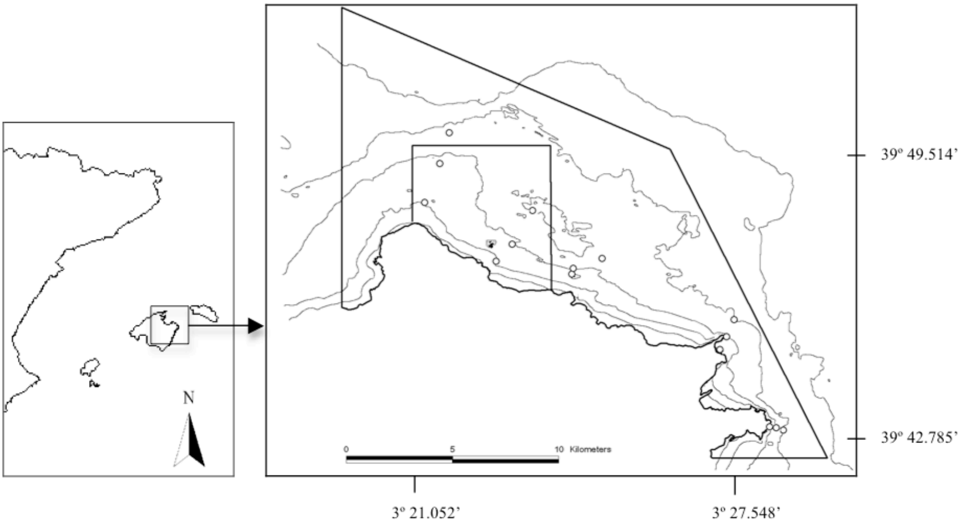


Fig. 1. Location of the sampled stations in Peninsula de Llevant marine reserve, Mallorca, Balearic Islands.
Fig. 1. *Localització de les estacions de mostreig a la reserva marina de la península de Llevant, Mallorca, Illes Balears.*

Methods

Study site

The fieldwork took place in and around the MPA of Cala Rajada at Mallorca Island during summer 2009 (Fig. 1).

The Cala Rajada MPA is located in the northeast coast of Mallorca Island (Balearic Archipelago), comprising a total protected area of 11,000ha with varied topography. The western part of the reserve is dominated by a uniform and extensive meadow of *Posidonia oceanica* adjoining well-structured and preserved coralligenous and maërl bottoms.

By contrast, the substrate in the eastern part is more fragmented, showing a combination of soft bottoms with scattered patches of *Posidonia oceanica*, precoralligenous and detritic shore bottoms, along with expanses of sand.

Field sampling

The field sampling took place from the 26th to 30th of June 2009. The area was divided into five transects perpendicular to the coast over the 20-40m isobaths. Samples were collected during the night, using light traps at three water depths, (2m from the bottom, mid water and 2m from the surface) forming a grid of 15 stations. Light trap design was based on that used in Granek and Fraiser (2007) (Fig. 2). The devices were constructed using inverted 20L clear plastic water containers, which had a PVC tube attached to the bottle mouth. This PVC piece was perforated and covered with a mesh of 220µm. The specimens had three entry points made through funnel-shaped openings pierced on the bottle sides, leading inwards to a 1cm diameter hole. 70 Cyalume Lightsticks ® suspended from the top of each trap inside the bottle were used as light source.

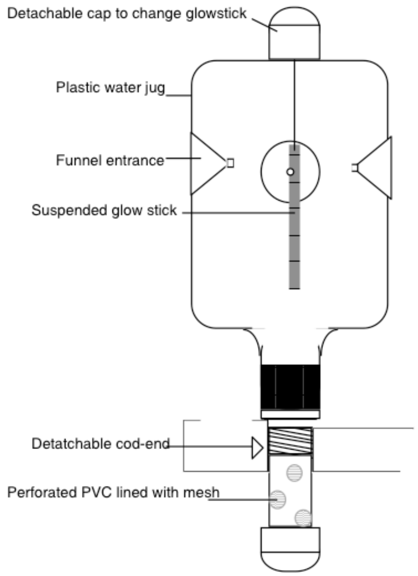


Fig. 2. Light trap design modified from Granek and Fraiser (2007).
Fig. 2. *Disseny de la trampa de llum modificada de Granek i Fraiser (2007).*

Samples were stored frozen for ulterior analysis. In the laboratory, the specimens were sorted, counted and identified using a binocular microscope. When possible all decapod larvae were identified to the lowest taxonomic level following the descriptions and identification keys given by Ingle (2002) and dos Santos & Gonzalez-Gordillo (2004). The samples showing very high densities were divided into subsamples using a Motoda Splitting Box (Motoda, 1959) and a Folsom Plankton splitter; those abundances were then referred to the initial volume.

Data analysis

Several analyses were carried out with the aim of detecting potential differences in vertical and horizontal abundance patterns. Vertical distribution was tested using depth and position of light traps in the water column, while horizontal distribution was tested comparing the abundances inside the non-take area, where fishing and scuba diving are prohibited and outside the non-take area, where those activities are permitted. We also compared the western part of the marine reserve, characterized by a flat continental platform and *Posidonia oceanica* meadows, including the stations of Farrutx, Faralló d'Aubarca and Trinquet des moro; with the eastern part of the reserve, including stations of Capdepera and Cap des Freu, characterized by an abrupt platform and a variety of bottom, ranging from rocky and sandy bottoms to *Posidonia oceanica* meadows. For the analysis, non-parametric tests were carried out for two species group, crustacean taxa as a whole and megalopa brachyura only. The abundance data for each station were log-transformed to reduce the weight of dominant taxa and a Bray-Curtis similarity matrix was created assuming a cut-off at 90%. Subsequently, the similarity ordinations resulting from this data were represented graphically with non-parametric multidimensional scaling (MDS) plots. In order to test differences between samples, one-way analysis of similarities (ANOSIM) was performed. In addition, diversity values of specific richness, Shannon index (Shannon, 1963) and evenness values (Pielou, 1969) were determined for each marine reserve. All multivariate analyses were performed using the software package PRIMER© V6 (Primer-E Ltd, Plymouth, UK).

Results

Species composition

A total of 72855 epibenthic and meroplanktonic organisms belonging to 35 taxa were captured on the water column in the study area (Table 1); 98’74% from the total were crustaceans, while the remaining 1.26% included organisms of ictioplankton, Polychaete and Gastropoda.

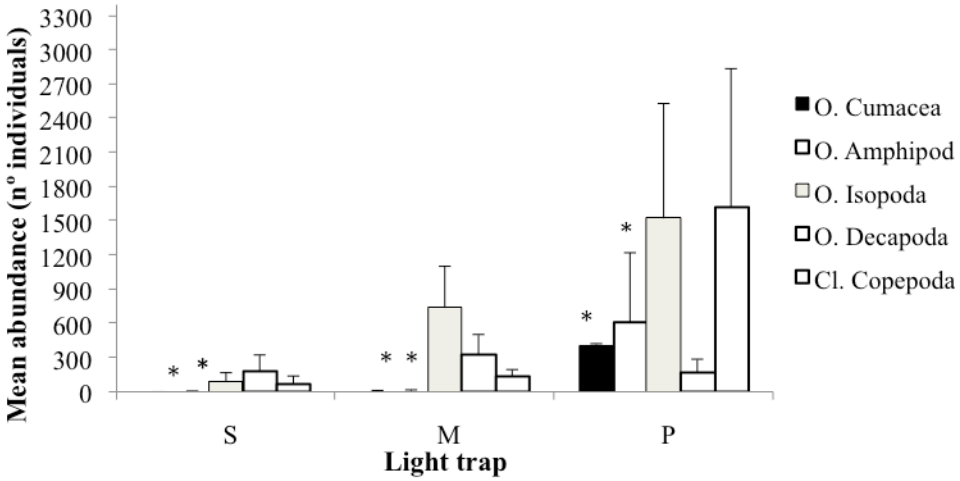
The most abundant taxa was Isopoda, mostly from the family Gnathiidae (34.94%), followed by Copepoda (16.57%), Amphipoda (16.04%), Cumacea (12.14%) and Decapoda larvae (14.34%). The remaining 10 taxa together represented the remaining 5.97%. Among the Decapoda larvae fraction, brachyuran was the most abundant group (66.30%), megalopa larval stages represented the 85.52 %, with *Monodaeus couchii* and specimens from the family Portunidae as the most abundant specimens.

	Farrutx		Trinquet des moro		Faralló d'Aubarca		Cap des Freu		Cap de Pera		TOTAL	
Taxa	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ictioplankton	0,56	1,01	0,44	1,33	0,56	1,67	1,67	2,60	0,89	1,54	4,11	0,50
Phylum Anellida, Cl. Polychaete	11,56	10,78	15,00	16,73	59,11	65,12	5,67	6,36	6,44	11,49	97,78	22,44
Phyllum Mollusca, Cl. Gasteropoda	0,11	0,33	0	0	0	0	0	0	0	0	0,11	0,05
O. Amphipoda (1)	91,44	141,44	191,22	311,42	44,44	71,02	763,89	1419,82	207,56	328,61	1298,56	289,94
SubO. Gammaridea	91,44	141,44	189,44	312,49	44,33	71,08	763,89	1419,82	207,56	328,61	1296,67	290,07
SubO. Caprellidea	0	0	0,22	0,67	0,11	0,33	0	0	0	0	0,33	0,10
SubO. Hyperidea	0	0	1,56	3,97	0	0	0	0	0	0	1,56	0,70
Cl . Copepoda (2)	28,89	43,27	31,56	51,06	20,56	24,89	650,56	956,11	609,33	1300,03	1340,89	330,59
O. Calanoida	27,56	42,56	31,56	51,06	20,56	24,89	650,56	956,11	609,22	1300,06	1339,44	330,81
O. Harpacticoida	1,33	2,83	0	0	0	0	0	0	0,11	0,33	1,44	0,59
O. Cumacea	180,44	467,54	319,11	505,23	74,89	128,33	270,56	454,69	138,11	204,22	983,11	98,71
O. Isopoda (3)	574,67	1428,40	238,33	437,94	327,33	705,67	939,44	1575,37	762,00	1120,59	2828,11	292,51
F. Gnathiidae	573,56	1425,81	238,33	437,94	314,78	701,69	939,44	1576,29	762,00	1109,62	2828,11	295,13
Cl. Ostracoda, O. Myodocopida	9,11	18,09	187,22	349,31	11,00	17,39	100,11	240,54	13,78	19,36	321,22	78,79
O. Euphausiacea	0	0	0,89	2,67	0	0	12,89	20,30	0,56	1,33	14,33	5,62
O. Mysidacea	11,00	18,39	65,78	97,76	33,78	33,17	20,44	21,59	1,67	2,83	132,67	24,95
O. Leptostraca	4,67	13,27	1,44	2,79	0	0	2,11	3,48	0,44	1,33	8,67	1,84
O. Tanaidacea	6,33	13,67	8,56	17,10	6,44	15,13	20,44	55,59	11,11	27,61	52,89	5,85
O. Stomatopoda	0,33	0,50	0,22	0,67	1,00	3,00	0,67	1,00	0	0	2,22	0,39
O. Decapoda (4)	66,56	121,50	34,00	33,53	93,67	133,98	718,89	784,62	247,67	231,56	1160,78	284,17
Zoea unidentified	1,22	2,64	3,00	7,16	2,44	1,88	5,67	10,71	24,00	27,14	36,33	9,49
InfraO. Anomura (5)	1,11	1,54	0,56	1,33	1,78	1,92	52,78	94,12	32,44	39,87	88,67	23,82
Zoea	0,22	0,67	0,33	0,71	0,11	0,33	5,78	11,19	0,56	1,33	7,00	2,45
Megalopa	0,89	1,36	0,22	0,67	1,67	1,94	47,00	84,27	31,89	39,50	81,67	21,77
InfraO. Brachyura (6)	62,33	117,21	28,00	25,25	86,78	126,26	584,44	588,60	181,00	187,43	753,00	228,50
Zoea	5,78	7,97	1,67	1,41	4,78	5,21	92,00	164,24	4,78	6,91	109,00	39,27
Megalopa unidentified	4,00	8,70	4,11	4,34	22,22	46,86	174,00	238,17	26,22	24,68	230,56	72,21
F. Leucosiidae, *Ebalia sp.*	1,00	3,00	0,22	0,67	0,44	0,73	8,33	15,38	6,22	11,01	16,22	3,77
F. Majidae	0,22	0,44	0,22	0,67	0	0	32,67	66,22	1,56	3,68	34,67	14,40
F. Pinntoheridae, *Pinnotheres sp.*	0,11	0,33	0	0	0	0	5,33	7,40	1,56	3,13	7,00	2,30
F. Portunidae	8,11	23,96	1,22	2,73	1,78	2,59	10,78	29,45	0,33	0,71	22,22	4,69
F. Portunidae, SF. Polybiinae unidentified	29,22	85,05	5,44	7,70	12,56	19,34	51,00	86,89	79,22	107,69	177,44	30,09
F. Portunidae, SF. Polybiinae type 2	0	0	0,11	0,33	21,22	28,90	11,22	33,67	2,67	3,50	35,22	9,16
F. Portunidae, SF. Polybiinae type 3	1,56	3,94	1,56	3,97	0	0	14,22	26,84	0	0	17,33	6,06
F. Portunidae, SF. Polybiinae type 4	0,22	0,67	1,11	2,67	0	0	10,33	30,25	0,22	0,67	11,89	4,47
F. Portunidae, SF. Polybiinae type 5	0,56	0,88	0	0	0,22	0,44	0	0	0,44	1,33	1,22	0,25
F. Xanthidae, *Monodaeus couchii*	6,11	11,36	7,00	14,47	18,11	35,98	21,56	59,83	37,33	53,14	90,11	12,74
Phyllsoma, F. Scyllaridae, *Scyllarus sp.*	0	0	0	0	0,11	0,33	0	0	0,00	0,00	0,11	0,05
InfraO. Caridea (7)	1,89	2,67	2,44	5,20	2,67	6,91	76,00	167,07	10,22	22,44	93,22	32,25
Zoea	1,89	2,67	2,44	5,20	2,67	6,91	76,00	167,07	10,22	22,44	93,22	32,25
Unidentified	1,67	2,74	0,44	1,33	0	0	1,00	2,65	0	0	3,11	0,71
Total	8837		9800		6007		30217		17994		72855	

(1): total number of amphipods / (2): total number of copepods / (3): total number of isopods (4): includes zoea unidentified, InfraO. Anomura, Brachyura and Caridea
(5): total number of anomuran larval stages/ (6): total number of brachyuran larval stages
(7): total number of caridean larval stages

Taula 1. Taxonomic composition of organisms caught in Cala Rajada MPA during June 2009.

Table 1. *Composició taxonòmica dels organisms presents a Cala Rajada MPA durant el juny de 2009.*



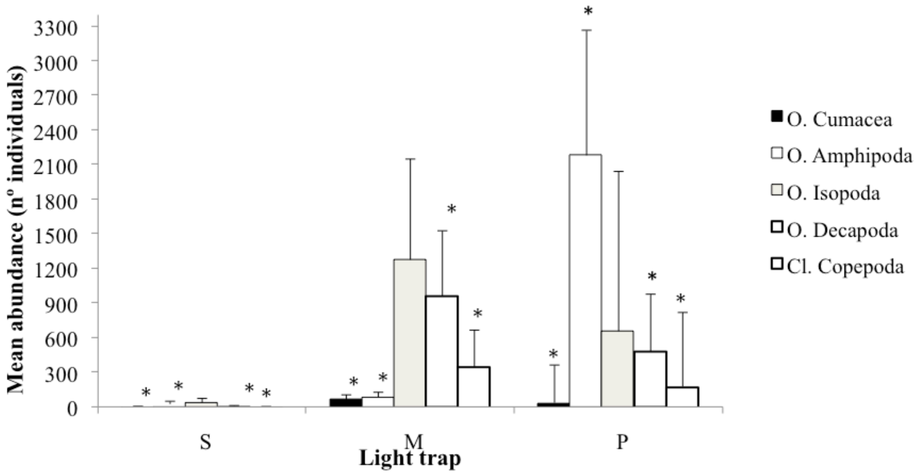
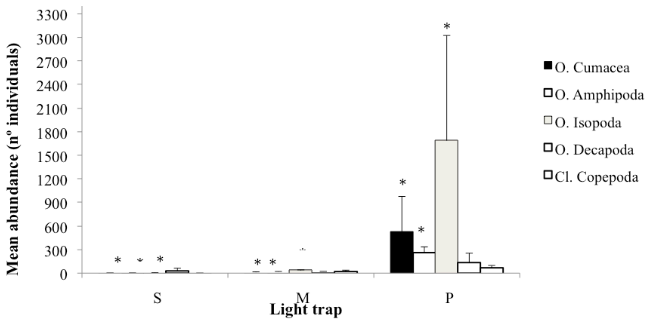


Fig. 3. Mean abundance of the main taxa caught on the water column in Cala Rajada's stations, Cap des Freu (Upper), Capdepera (Lower). (S: near-surface trap, M: mid-water trap, P: near-bottom trap). Vertical bars represents standard error; *, represents significant differences ($p<0.001$).

Fig. 3. *Abundància mitja dels principals tàxons capturats en la columna d'aigua en les estacions de Cala Ratjada, Cap des Freu (Superior), Capdepera (Inferior). (S:prop de la superfície, M: mitja aigua, P: prop del fons). Les barres verticals representen l'error standard; *, indica diferències significatives (p<0.001).*



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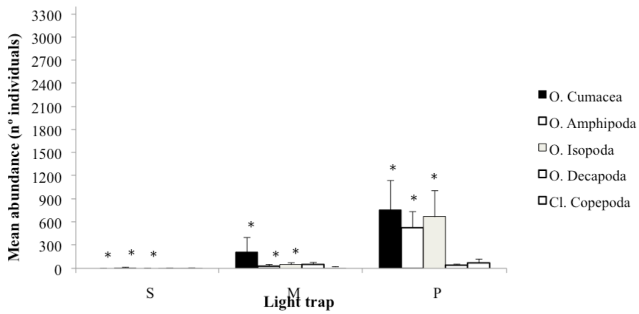

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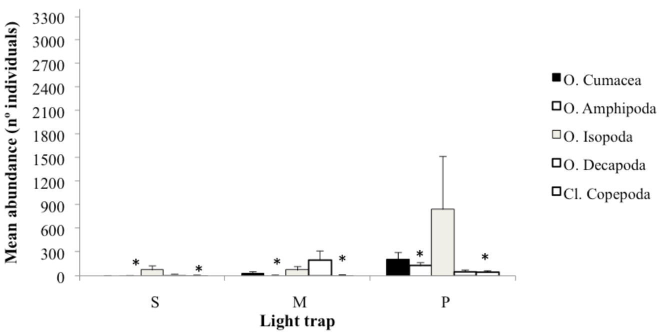

Fig. 3. Mean abundance of the main taxa caught on the water column in Cala Rajada's stations, Farrutx (Upper), Trinquet des Moro (Middle) and Faralló d'Aubarca (Lower). (S: near-surface trap, M: mid-water trap, P: near-bottom trap). Vertical bars represents standard error; *, represents significant differences (p<0.001).

Fig. 3*. Abundància mitja dels principals tàxons capturats en la columna d'aigua en les estacions de Farrutx (superior), Trinquet des Moro (central) and Faralló d'Aubarca (inferior). (S:prop de la superfície, M: mitja aigua, P: prop del fons). Les barres verticals representen l'error standard; *, indica diferències significatives (p<0.001).*

Diversity values were calculated by depths in each station; diversity was slightly higher in western stations than in eastern stations, with an average of 1.62 and 1.46 in the Shannon index. In western stations diversity values increased with depth, with the exception of Faralló d'Aubarca, where diversity was higher at 30m. Eastern stations showed higher diversity values between 20 and 30 m.

Spatial variability

The analysis of the abundance of crustacean taxa, revealed a vertical distribution pattern with lower values in the near-surface traps and higher values in the near-bottom traps (Fig. 3a-3e). ANOSIM routine revealed that these differences were significant (Global R=0.391, p=0.001). Brachyuran megalopa were an exception, with higher abundance at mid-water traps. No significant differences were found when comparing the abundances between depths, although higher abundances were found at 40m. Regarding a possible horizontal pattern, bigger abundances were found out of the non-take area; moreover, the analysis suggested a decreasing gradient with higher abundance at stations near the coast and lower at further stations, but results were not significant.

Abundances of the most common taxa found in the water column are shown in Fig. 4. Surface traps showed highest abundances of decapods; mid-water of isopods and bottom samples of cumaceans, amphipods and copepods.

Discussion

Prior to this study, little was known about the small-scale spatial distribution of crustacean larval in Western Mediterranean shallow waters. These data widen the knowledge on crustacean distribution, especially decapods, in the Mediterranean Sea, and more specifically at the largest Mallorcan Marine Reserve, Peninsula de Llevant.

The higher number of larval decapods captured is consistent with the spawning period and larval development, which in the western part of the Mediterranean Sea takes place in spring and early summer for most of species. Moreover, the higher proportion of megalopa larval stages among the brachyura group suggests this marine protected area could act as a retention zone. This reflected the neritic distribution of these larval stages, similarly as it was described in the Catalan coast by Fusté (1989) and Olivar (1998). The different types, in relation to the vertical distribution, the higher number of epibenthic crusta-ceans, including isopods, cumaceans and amphipods captured with light traps explains the highest captures at near-bottom traps. Decapoda larvae were an exception, with highest abundances in mid-water traps as they undergo nictimeral migrations, taking shelter near the bottom by day and entering the water column at a particular time of the night (Tranter *et al.,* 1981).

Moreover, the analysis suggested a horizontal pattern in relation to the distance to coastline in crustaceans but especially in brachyuran megalopa larval stages as bigger abundance were found near the coastline decreasing as we move inwards; of bottom found outside the non-take area and in the eastern stations, which vary from soft to rocky bottoms and *Posidonia oceanica* meadows, could explain the highest proportion of captures in these areas.

Light traps used in the present study have proved a valuable tool for sampling mobile phototactic crustaceans, such as cumaceans, isopods or decapods, but not suitable for capturing larval fishes, as captures did not exceed the 0.05% from the total.

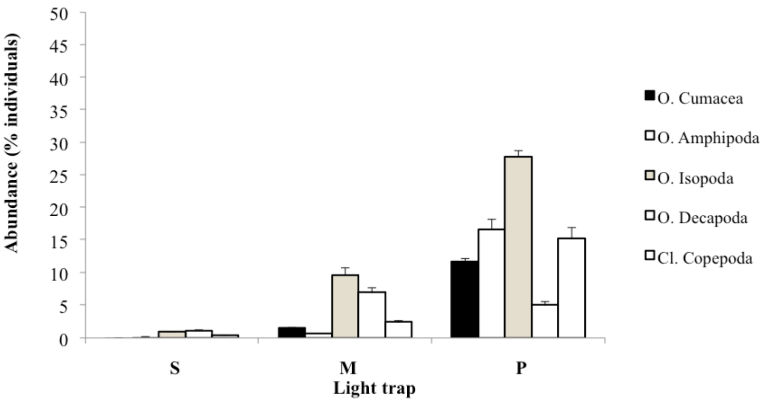

Fig. 4. Relative abundance of the main taxa caught on the water column.Vertical bars represents standard error.

Fig. 4. *Abundància relativa dels principals tàxons en la columna d'aigua. Les barres verticals representen l'error estàndard.*

This study provides an overview of crustacean larval small-scale distribution, although further studies are needed. It will be interesting in the future to continue study the larval dynamics, in order to improve the management of the marine protected areas.

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References

Abelló, P. and Guerao, G. 1999. Temporal variability in the vertical and mesoscale spatial distribution of crab megalopae (Crustacea: Decapoda) in the Northwestern Mediterranean. *Estuarine, coastal and shelf science,* 49: 129-139.

Choat, J., Doherty, P., Kerrigan B. and Leis, J. 1993. A comparison of towed nets, purse seine and light-aggregation devices for sampling larvae and pelagic juveniles of coral reef fishes. *Fishery bulletin***,** 91(2): 195-209.

Clarke, K. and Warwick, R. 2001. *Change in marine communities: an approach to statistical analysis and interpretation*. 2nd edition. Plymouth, UK: PRIMER-E, 172pp.

Deudero S. 2002. Unexpected large numbers of *Mullus surmuletus* juveniles in open waters of the Mediterranean sampled with light attraction devices. *Journal of Fish Biology,* 61(6): 1639-1642.

Doherty, P. 1987. Light-traps: selective but useful devices for quantifying the distributions and abundances of larval fishes. *Bulletin of marine science*, 41(2): 423-431.

Dos Santos, A. and González- Gordillo, J.I. 2004. Illustrated keys for the identification of the Pleocyemata (Crustacea: Decapoda) zoeal stages, from the coastal region of south-western Europa. *J. Mar. Biol. Ass. U.K*, 84: 203-227.

Fernández de Puelles, M.L., Grás, D. and Hernández-León, S. 2003. Annual cycle of zooplankton biomass, abundance and species composition in the neritic area of the Balearic Sea, West Mediterranean. *Marine Ecology*, 24(2): 123-139.

Fernández de Puelles, M.L., Valencia, J., Jansá, J. and Morillas, A. 2004. Hydrographical characteristics and zooplankton distribution in the Mallorca channel (Western Mediterranean): spring 2001. *Journal of Marine Science*, 61: 654-666.

Forward, R. 1990. Behavioural responses of crustacean larvae to rates of temperature change. *Biological bulletin*, 178: 195-204.

Fusté, X. 1989. Distribution of decapod crustacean larvae in the bays of the Ebro Delta. *Scientia marina*, 53(4): 763-770.

González- Gordillo, J. and Rodríguez, A. 2003. Comparative seasonal and spatial distribution of decapods larvae assemblages in three coastal zones off the south-western Iberian Peninsula. *Acta Oecologica*, 24: 219-233.

Granek, E.F. and Fraser, K. 2007. The impacts of red mangrove (Rhizophora mangles) deforestation on z ooplankton communities in Bocas del Toro, Panama. *Bulletin of marine science*, 80(3): 905-914.

Hays, G. 2003. A review of the adaptative significance and ecosystem consequences of zooplankton migration. *Hydrobiologia*, 503: 163-170.

Hovda, J.L. and Fosshagen, A. 2003. Hyperbenthic calanoids and *Thespesiopsyllus paradoxus* (Sars) collected with a light trap in western Norway. *Sarsia*, 88: 89-94.

Ingle, R. 1992. *Larval stages of northeastern atlantic crabs. An illustrated key*. Natural History Museum Publications. 384pp.

Landeira, J.M., Lozano- Soldevilla, F., Hernández- León, S. and Burton, ED. 2009. Spatial variability of planktonic invertebrate larvae in the Canary Islands area. *Journal of the marine biological association of the United Kingdom*, 90: 1217-1225.

Meekan, M., Wilson SG., Halford, A. and Retzel, A. 2001. A comparison of catches of fishes and invertebrates by two light trap design, in tropical NW Australia. *Marine biology*, 139: 373-381.

Olivar, M., Sabates, A., Abelló, P. and Garcia, M. 1998. Transitory hydrographic structures and distribution of fish larvae and neustonic crustaceans in the NW Mediterranean. *Oceanologca acta***,** 21(1): 95-104.

Palumbi, S. 2003. Population genetics, demographic connectivity, and the design of marine reserve. *Ecological applications*, 13(1): 146-158.

Shanks, A., Grantham, B. and Carr, M. 2003. Propagule dispersal distance and the size and spacing of marine reserves. *Ecological applications*, 13(1): 159-169.

Tranter, D., Bulleid, N., Campbell, R., Higgins, H., Rowe, F., Tranter, A. and Smith, D. 1981. Nocturnal movements of Phototactic Zooplankton in Shallow waters. *Marine Biology*, 61: 317-326.

Zaret, T. and Suffern, J. 1976. Vertical migration in zooplankton as a predator avoidance mechanisms. *Limnology and oceanography*, 21(6): 804- 813.