Habitat diversity and postlarval benthic decapod crustacean assemblages in shallow waters of the Ría de A Coruña (NW Spain)

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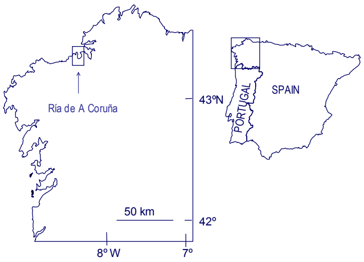
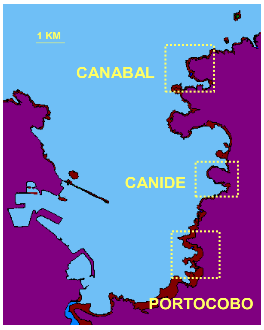
INTRODUCTION

Distribution and abundance of postlarval phases of coastal benthic decapod crustaceans is related to multiple processes affecting both planktonic (larval supply and differential settlement) and benthic (differential mortality, habitat selection and denso-dependence) stages. The high diversity of decapod assemblages in coastal ecosystems results from the interaction between the above processes and the existing high environmental variability and habitat diversity. This study is an attempt to characterize patterns of habitat use and distribution of juvenile and adult stages of benthic postlarval decapod species in shallow bottoms, identifying the main environmental variables affecting these patterns. The comparative capacity of different habitats to support juvenile and adult diversity was also characterized.

SAMPLING

A stratified random survey was carried out along the coast of the Ria de A Coruña (Galicia, NW Spain) during the months of July and August 1998, using a suction sampler operated by divers. Three sampling sites along the main axis of the Ria were selected to identify the meso-scale variability and an array of sampling locations were defined within each site according to the combination of three micro-scale variables: wave exposure, depth and habitat type. Four replicates were taken in each location.





- Wave exposure:
Exposed
Sheltered

- Depth:
0: Intertidal
1: 3-5 m
2: 8-12 m

- Habitat type:
    Sandy bottoms
    Rocky bottoms: Flat rock surfaces covered with algae
    Cobble and boulder pools
    Kelp (*Saccorhiza polyschides*) holdfasts

ANALYSIS.

Generalized linear models (GLM) were employed to determine the weighted effect of the environmental conditions over the spatial patterns of the postlarval community. The best subsets procedure using the Akaike Information Criterion (AIC) was used to select the best model, and a normal log model was assumed.

Null models were employed to extract common diversity patterns among variable combinations. Individual-based rarefaction curves (Gotelli and Graves, 1996), which generate comparative estimates of species number independently of the differences between sample size of the groups compared, were employed as a richness index. The probability of an interspecific encounter PIE (Hurlbert, 1971) was used as an evenness measure. The abundance levels for simulation were fixed according to the sample with lowest abundance to allow the comparison among samples. Both evenness and rarefaction were estimated using EcoSim software (Gotelli and Entsminger, 2001), which uses a Monte Carlo procedure, and 1000 replicate simulations were performed for each estimate.

RESULTS

Shallow bottoms of the Ria de A Coruña show a wide diversity of habitats and support a highly abundant and diverse community of decapods. Our results support the hypothesis that these areas constitute essential nursery habitats for benthic species.

A lower specific diversity was found for adults than for juveniles in nearly all cases (Fig. 1). This difference was more pronounced in Canabal (the most external sampling site). Evenness values for both stages were high (Average PIE > 0.65) in most sampling locations (Table 1). The most internal site (Portocobo) presented a higher homogeneity in richness and evenness values for adults than for juveniles.

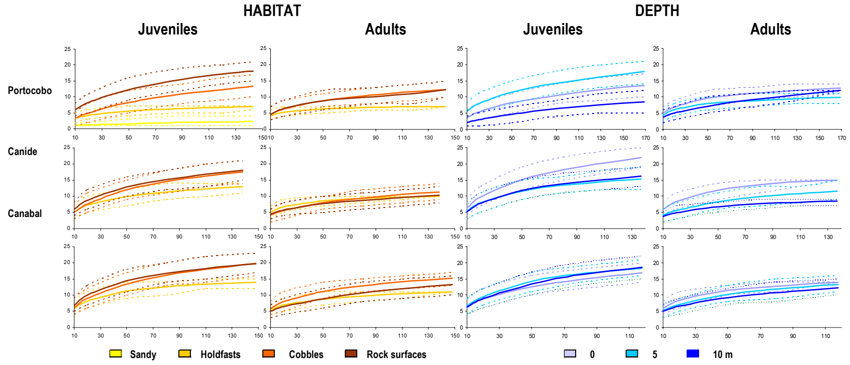


Fig. 1. Rarefaction diversity curves. The Y axis represents the expected richness for a given sample size (no. of individuals)

Table 1. Evenness values

HABITAT		**Abund. level**	**Juveniles**		**Adultos**	
			Average PIE	**Variance PIE**	**Average PIE**	**Variance PIE**
Portocobo	**Sandy**	**143**	**0,021**	**0,00026**		
	Holdfasts		**0,566**	**0,00046**	**0,715**	**0**
	Cobbles		**0,451**	**0,00184**	**0,836**	**0,00005**
	Rock surfaces		**0,858**	**0,00014**	**0,716**	**0,0007**
Canide	**Holdfasts**	**138**	**0,790**	**0,00023**	**0,774**	**0**
	Cobbles		**0,739**	**0,00094**	**0,667**	**0,00106**
	Rock surfaces		**0,856**	**0,00024**	**0,741**	**0,00048**
Canabal	**Holdfasts**	**148**	**0,860**	**0,00008**	**0,844**	**0**
	Cobbles		**0,861**	**0,00026**	**0,851**	**0,00006**
	Rock surfaces		**0,902**	**0,00009**	**0,815**	**0,0001**

DEPTH	**Abund. level**	**Juveniles**		**Adultos**	
		Average PIE	**Variance PIE**	**Average PIE**	**Variance PIE**
Depth 0	**169**	**0,525**	**0,00137**	**0,762**	**0,00026**
Depth 1		**0,839**	**0,00018**	**0,689**	**0,00044**
Depth 2		**0,206**	**0,00155**	**0,693**	**0**
Depth 0	**137**	**0,861**	**0,0002**	**0,859**	**0**
Depth 1		**0,795**	**0,0007**	**0,690**	**0,00086**
Depth 2		**0,760**	**0,00069**	**0,664**	**0,00036**
Depth 0	**118**	**0,870**	**0,00016**	**0,853**	**0**
Depth 1		**0,886**	**0,00017**	**0,816**	**0,00023**
Depth 2		**0,870**	**0,00021**	**0,805**	**0,00021**

The most abundant species occurred in higher density for juvenile over adult stages in most cases (Fig. 2). All adults belonged to species also found for juveniles. Three main patterns of juvenile and adult distribution were identified: species without adult presence in the sampled area, such as *Galathea strigosa*; species that remain in the same area, but with observable ontogenic habitat shifts, which is the case of *Eualus occultus* and species that keep similar habitat use patterns along the life cycle, e.g. *Pisidia longicornis*.

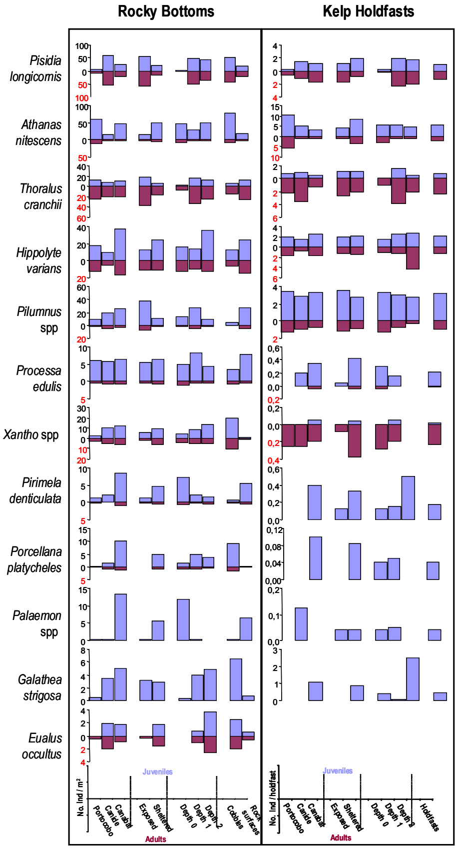


Fig. 2. Densities of juveniles and adults of the most abundant species in different sites, exposure levels, depths and habitats

Although all the tested variables showed an important effect on the distribution of decapod species, variability in spatial patterns is mainly due to habitat type, which is a micro-scale operating factor. Meso-scale variability related to sites along the Ria, as well as other micro-scale factors, i.e. depth and wave exposure, have a lower effect on spatial distribution of post-recruits.

A similar pattern in the composition of parameters included in the most parsimonious models (GLM) was found between juveniles and adults on rocky bottoms (Table 2). In both cases habitat type was the most frequent variable in models for the most abundant species (87.5% for juveniles; 64.3% for adults), while wave exposure shows the lowest percentage of occurrence in models for both juveniles (56.2%) and adults (50%).

The GLM results for kelp holdfast samples showed a lower effect of all the factors on juvenile and adult patterns, with no observable differences among variables. A high proportion of the models obtained for this group of samples were not significant. This suggests that the influence of environmental conditions could be attenuated inside kelp holdfasts. These results, altogether with the ontogenic distribution patterns of the species found in holdfasts as well as the significant differences observed in diversity between them and rocky habitats, suggest that holdfasts are used as a temporary shelter rather than a nursery habitat.

Sandy bottom coverage was significant only in sheltered areas of one sampling site and therefore GLM was not fitted. The diversity and evenness found in this habitat were very low due to the dominance of the Paguridea. Early juveniles of this group showed an average density of 427 Ind/m² (Fig. 3), reaching 1227 Ind/m² at 10 m deep. Data found support the hypothesis that these bottoms are essential recruitment habitats for this group.

Table 2. GLM models for rocky bottoms and kelp holdfasts

ROCKY BOTTOMS

	Habitat		Sampling site		Depth		Exposure		Degrees of Freedom		AIC		p	
	J	A	J	A	J	A	J	A	J	A	J	A	J	A
Paguridea	🟪	⬜	🟪	⬜	🟪	🟫	⬜	🟫	5	3	580,69	599,02	**	**
Pisidia longicornis	🟪	🟫	🟪	🟫	🟪	🟫	🟪	🟫	6	6	761,47	746,53	**	**
Athanas nitescens	🟪	🟫	🟪	🟫	⬜	🟫	⬜	🟫	3	5	853,99	36,03	**	0,03
Thoralus cranchii	⬜	🟫	⬜	⬜	🟪	🟫	🟪	⬜	3	4	557,14	664,91	**	**
Hippolyte varians	🟪	🟫	🟪	🟫	🟪	⬜	⬜	⬜	5	3	591,01	471,58	**	**
Pilumnus hirtellus	🟪	🟫	⬜	🟫	🟪	🟫	🟪	🟫	4	6	558,43	222,04	**	**
Pilumnus spinifer	🟪	🟫	🟪	🟫	⬜	⬜	🟪	🟫	4	4	448,60	292,23	**	**
Processa edulis	🟪	⬜	⬜	⬜	🟪	⬜	🟪	🟫	4	1	438,12	134,11	0,02	0,36
Xantho pilipes	🟪	🟫	🟪	🟫	🟪	🟫	🟪	⬜	6	5	416,78	292,35	**	**
Xantho incisus	🟪	🟫	🟪	⬜	🟪	🟫	⬜	⬜	5	3	350,50	296,99	**	**
Hippolyte sp.	🟪	⬜	⬜	⬜	⬜	⬜	⬜	🟫	1	1	318,66	182,25	0,12	0,29
Pirimela denticulata	🟪	⬜	🟪	🟫	🟪	⬜	🟪	⬜	6	2	424,29	103,93	**	0,02
Porcellana platycheles	🟪	🟫	🟪	🟫	⬜	⬜	⬜	⬜	3	3	442,98	150,48	**	**
Palaemon longirostris	⬜	▨	🟪	▨	🟪	▨	🟪	▨	5	▨	594,87	▨	**	▨
Galathea strigosa	🟪	▨	🟪	▨	🟪	▨	🟪	▨	6	▨	348,89	▨	**	▨
Eualus occultus	🟪	⬜	🟪	⬜	🟪	🟫	⬜	⬜	5	2	264,77	266,42	**	0,05
Percentage	87,5	64,3	75,0	57,1	75,0	57,1	56,2	50,0					** p < 0,01	

KELP HOLDFASTS

	Sampling site		Depth		Exposure		Degrees of Freedom		AIC		p	
	J	A	J	A	J	A	J	A	J	A	J	A
Paguridea	⬜	⬜	🟪	🟫	⬜	⬜	2	2	219,33	169,74	**	0,06
Pisidia longicornis	🟪	⬜	🟪	🟫	⬜	🟫	4	3	158,72	181,19	**	**
Athanas nitescens	🟪	🟫	⬜	⬜	🟪	🟫	3	3	346,98	263,11	0,05	**
Thoralus cranchii	⬜	🟫	🟪	🟫	🟪	⬜	3	4	147,21	228,30	**	**
Hippolyte varians	⬜	⬜	🟪	🟫	⬜	⬜	2	2	206,39	199,48	0,23	0,02
Pilumnus hirtellus	🟪	🟫	⬜	🟫	⬜	⬜	2	4	221,59	139,13	0,08	0,02
Pilumnus spinifer	🟪	🟫	🟪	⬜	⬜	⬜	4	2	119,22	77,20	**	**
Processa edulis	⬜	⬜	⬜	⬜	🟪	🟫	1	1	94,67	-47,64	0,07	0,31
Xantho pilipes	▨	⬜	▨	⬜	▨	🟫	▨	1	▨	-47,64	▨	0,31
Xantho incisus	⬜	⬜	⬜	⬜	🟪	🟫	1	1	-47,64	70,22	0,31	0,08
Hippolyte sp.	⬜	⬜	⬜	🟫	🟪	⬜	1	2	93,91	-11,34	0,82	**
Pirimela denticulata	🟪	▨	⬜	▨	⬜	▨	2	▨	78,77	▨	0,04	▨
Porcellana platycheles	⬜	▨	⬜	▨	🟪	▨	1	▨	-16,51	▨	0,14	▨
Palaemon longirostris	🟪	▨	⬜	▨	⬜	▨	2	▨	-16,74	▨	0,11	▨
Galathea strigosa	⬜	▨	🟪	▨	⬜	▨	2	▨	164,14	▨	**	▨
Eualus occultus	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Percentage	42,9	36,4	42,9	54,5	42,9	45,5					** p < 0,01	

🟪	Variable included in model (juveniles)
🟫	Variable included in model (adults)
⬜	Variable not included in model
▨	Species not present

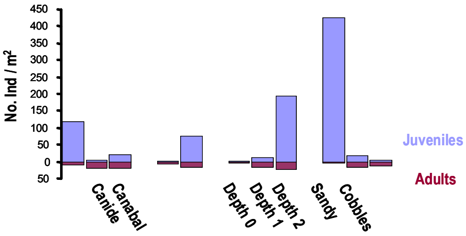


Fig. 3. Densities of juveniles and adults of the group Paguridea in different sites, exposure levels, depths and habitats

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