

## Condition of *Salaria pavo* in the Mar Menor coastal lagoon (SE Iberian Peninsula): potential influence of environmental variables on juveniles

By D. Verdiell-Cubedo, F. J. Oliva-Paterna and M. Torralva

Department of Zoology, University of Murcia, Murcia, Spain

### Summary

The relationship at the local level between fish condition and environmental variables was investigated in *Salaria pavo* (peacock blenny) juveniles. The relationships between fish condition and 18 environmental variables of shallow areas of the lagoon relating to intra- and interspecific fish interactions, water quality and habitat structure, were analysed. The study revealed that water depth and *S. pavo* biomass (both related to intraspecific fish interactions) were the ecological variables accounting for most of the variation in the condition of *S. pavo* juveniles, in this case a negative effect. In this way, the condition of *S. pavo* juvenile populations may be a good indicator of fish density interactions.

### Introduction

Distribution of the peacock blenny, *Salaria pavo* (Risso, 1810), runs from the Mediterranean Sea to the Atlantic coasts of Morocco and France. *S. pavo* inhabits rocky and weedy pools and shallow waters and is common in brackish waters. Its prey are benthic invertebrates, especially molluscs. Reproduction occurs in spring and early summer (Zander, 1986). During the breeding season, males build and defend nests and care for the eggs (Gonçalves and Almada, 1997).

Peacock blenny is one of the dominant benthic fish species in the Mar Menor fish assemblage and reproduces within the lagoon (Pérez-Ruzafa et al., 2004). However, no studies exist on its biology and ecology.

In the management of fish populations it is common to analyse fish condition as a measure of both individual and cohort (e.g. age or size group) fitness (Jakob et al., 1996). Such measurements are generally intended to be indicators of tissue energy reserves and may characterize components of the environment in which the fish live (e.g. food and habitat availability, competition, predation, physical factors, parasitic infections and pollution) (Bergeron, 2000; Copp, 2003; Lloret and Planes, 2003; Oliva-Paterna et al., 2003). A low body condition can negatively affect survival, first maturity and the reproductive effort in subsequent phases of fish life history (Rätz and Lloret, 2003; Hoey and McCormick, 2004; Morgan, 2004).

For this reason, the study of fish condition, together with investigations concerning habitat characteristics, will allow a better understanding of the biology and ecology of fish populations. Moreover, fish condition indices are potential indicators for assessing habitat quality in marine ecosystems such as coastal lagoons and estuaries (Lloret et al., 2005).

The purpose of this paper was to determine the relationship between the somatic condition of *S. pavo* juveniles and several

environmental variables and indices relating to intra- and interspecific interactions, water quality and habitat structure. These included: fish species richness, size of larger *S. pavo* (total length, TL), *S. pavo* abundance and biomass, biomass/abundance ratio of *S. pavo*, benthic fish abundance and biomass, biomass/abundance ratio of benthic fish species, total fish abundance and biomass, biomass/abundance ratio of total fish, water temperature (°C), water salinity, depth (cm), submerged vegetation cover (%), submerged vegetation volume, substrate size (SS) and substrate heterogeneity (SH).

### Materials and methods

#### Study area

The Mar Menor is a hypersaline coastal lagoon located in a semiarid region in the south-east of the Iberian Peninsula (Fig. 1). One of the largest coastal lagoons in the Mediterranean region and Europe, with a surface area of 135 km<sup>2</sup> and

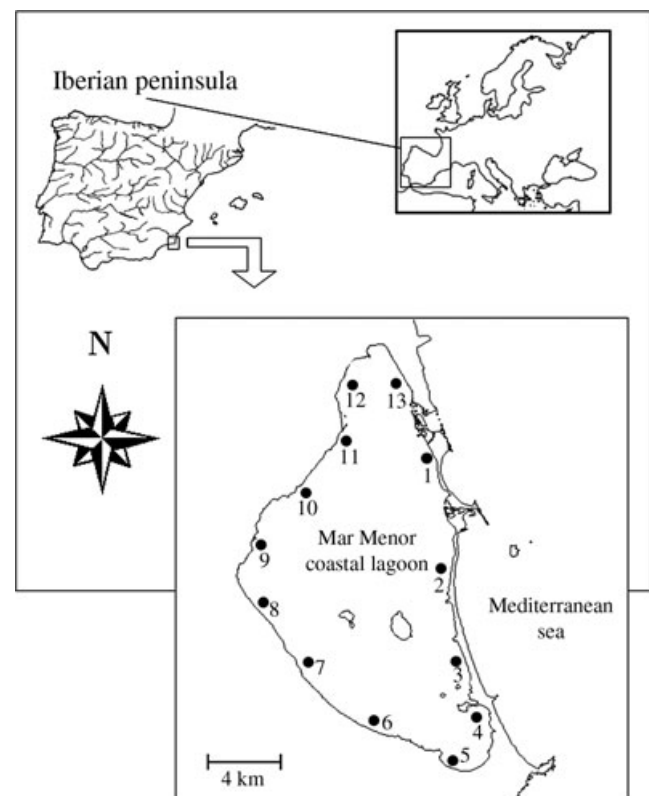


Fig. 1. Geographical location of the Mar Menor coastal lagoon and sampling sites

average depth of 3–4 m, it is separated from the Mediterranean Sea by a 22-km-long sandbar, with three narrow channels connecting it with the sea. The lagoon shows a salinity range of 39–45 and a temperature varying from 10°C in winter to 32°C in summer. The bottom is principally covered by dense meadows of the invasive macroalga *Caulerpa prolifera*, although shallow areas are covered by meadows of *Cymodocea nodosa* (Pérez-Ruzafa et al., 2004).

Since the 1970s the Mar Menor has suffered strong environmental changes after the widening of the connecting channels that caused a decrease in salinity from 50–52‰ to the present levels. Moreover, regular and intermittent watercourses flow into the lagoon, draining a large intensive agricultural area and leading to an important input of agrochemicals (Pérez-Ruzafa et al., 2000, 2002). Finally, the Mar Menor coastal lagoon supports important commercial fisheries and is subject to intensive tourist development (Andreu-Soler et al., 2003).

Sampling sites are located in littoral and shallow areas (maximum ≤100 cm) of the lagoon. The bottoms are characterised by soft substrates (principally muddy and sandy bottoms) and isolated patches of submerged vegetation (meadows of *Caulerpa prolifera* and *Cymodocea nodosa*).

### Sampling methods

The catches were carried out during the first two weeks of July 2003 as a part of a wider study to examine the effects of human activities on fish communities of the coastal lagoon.

A total of 13 sampling sites was selected in the perimeter coastal shallow areas. Samples were collected using a 10-m-long bag seine net of 0.5 mm mesh size, which allowed the collection of juvenile fish and adults of small size species. Six replicates were collected at each sampling site by adjacent 20 m reaches of shoreline at each site. In each reach, the bag seine was hauled offshore parallel to the shoreline in water < 1.0 m for the length of the reach. The area covered by each haul was approximately 160 m<sup>2</sup> (quantitative sampling).

Additional bag seine hauls and quadrangular (40 × 40 cm) hand net sweeps were made along the shoreline in each sampling area (the number of non-quantitative sampling, hauls and sweeps depending on the complexity of the shore). Our goal was to sample all shoreline habitats to detect species richness in a given sampling site.

Thus, seven replicate samples (six quantitative and one non-quantitative) were obtained at each of the 13 sampling sites, enabling us to assess variance within sites and the efficiency of seining.

Fish from each of the six reaches (quantitative samplings) and non-quantitative samplings were preserved in 7% formaldehyde, before being removed and identified at species level in the laboratory (Whitehead et al., 1986; Arias and Drake, 1990). Relative abundance was expressed as catch per unit effort (CPUEs) and biomass per unit effort (BPUEs):

$$\text{CPUEs} = \text{number of specimens}/100 \text{ m}^2,$$

$$\text{BPUEs} = \text{fish biomass (g)}/100 \text{ m}^2.$$

A total of 584 juvenile *S. pavo* (TL < 4.5 cm) from 13 sampling sites were measured for TL (± 1 mm) and total mass, TM (± 0.1 g). Fish larger than 4.5 cm were excluded from the condition analysis to avoid possible body shape differences between juveniles and adults (Murphy et al., 1990).

Table 1  
Environmental variables and fish community composition at sampling sites with specific emphasis on *Salaria pavo*

Sampling site	Size of larger <i>S. pavo</i> (TL)	Fish species richness	<i>S. pavo</i> abundance (CPUEs)	<i>S. pavo</i> biomass (BPUEs)	<i>S. pavo</i> B/A ratio	Benthic			Total fish			Water temperature (°C)	Salinity	Vegetation cover (%)	Vegetation volume	Depth (cm)	SS	SH
						Benthic fish biomass (BPUEs)	Benthic fish B/A ratio	Benthic fish abundance (CPUEs)	Total fish biomass (BPUEs)	Total fish B/A ratio	Total fish abundance (CPUEs)							
1 (Tomás Maestre)	6.23	15	4.06	2.78	0.68	20.29	96.77	0.21	128.54	41.19	0.32	27.99	43.36	40.83	2.08	65.00	2.09	0.39
2 (Las Brisas)	7.81	15	1.25	1.92	1.54	23.05	87.43	0.26	102.23	30.76	0.30	26.95	43.98	26.67	1.61	67.78	2.39	0.69
3 (Los Alisecos)	6.73	12	4.06	2.28	0.36	32.03	178.86	0.18	240.73	54.03	0.22	27.34	44.46	20.00	1.25	53.83	2.36	0.71
4 (Isla del Cervo)	–	10	18.13	11.49	0.63	20.21	54.69	0.37	115.21	57.43	0.50	28.39	44.21	35.83	1.75	42.67	2.22	0.81
5 (Playa Paraiso)	6.46	11	1.67	0.99	0.60	9.46	74.58	0.13	90.56	14.73	0.16	30.52	43.89	17.78	1.17	60.11	2.18	0.64
6 (Punta del Plome)	8.28	12	1.56	7.19	4.60	10.96	63.13	0.17	91.04	33.91	0.37	29.43	44.28	26.67	1.83	71.67	2.54	0.75
7 (Los Nietos)	5.68	10	5.63	3.96	0.70	4.24	19.58	0.22	116.36	35.19	0.30	28.77	44.57	34.17	1.75	61.50	2.11	0.58
8 (Los Urrutias)	5.36	13	6.14	4.54	0.74	16.88	53.64	0.31	188.13	68.09	0.36	27.57	44.74	51.67	2.75	41.00	1.83	0.63
9 (Los Alcazares)	5.76	12	28.02	14.88	0.53	6.59	50.31	0.13	158.33	58.73	0.37	28.41	42.81	49.17	2.42	43.00	1.65	0.46
10 (La Hita)	5.60	9	27.81	9.71	0.35	4.00	25.00	0.16	161.41	45.59	0.28	31.95	42.50	52.50	2.63	43.50	1.44	0.73
11 (Casablanca)	5.21	7	38.44	28.61	0.74	1.36	8.75	0.16	128.96	63.63	0.49	28.24	44.10	77.50	3.83	52.83	1.70	0.57
12 (Villa Nanitos)	5.60	11	7.50	3.75	0.50	10.36	84.06	0.12	153.23	36.15	0.24	29.13	43.58	30.83	1.92	62.00	1.95	0.38
13 (La Calceira)	6.26	12	3.23	4.95	1.53	17.48	43.96	0.40	188.64	56.11	0.30	26.86	43.87	62.50	3.17	61.33	2.16	0.78

CPUEs, catch per unit effort; BPUEs, biomass per unit effort; SS, substrate size; SH, substrate heterogeneity; TL, total length. Submerged vegetation volume: 0 (low density of meadows) to 5 (high density of meadows); Substrate size (average at each sampling site): [mud (1), sand (2), gravel (3), pebble (4) and boulder (5)]; Substrate heterogeneity (standard deviation at each sampling site).

Each sampling site was characterized by 18 environmental variables and indices (quantified in each reach of every sampling site) relating to intra- and interspecific interactions, water quality (weekly mean values) and habitat structure (local level): size of larger *S. pavo* (TL), fish species richness, *S. pavo* abundance and biomass, biomass/abundance ratio of *S. pavo*, benthic fish abundance and biomass, biomass/abundance ratio of benthic fish species, total fish abundance and biomass, biomass/abundance ratio of total fish, water temperature (°C), water salinity, depth (cm), submerged vegetation cover (%), submerged vegetation volume, SS and SH (Table 1).

Benthic fish or fish species captured at each sampling site that tended to move nearer the bottom and which had carnivorous diets (*sensu* Quignard and Pras, 1986; Dumay et al., 2004) were considered as potential competitors. In this way, total fish, benthic fish and *S. pavo* relative abundance and biomass were assessed as mean CPUEs and BPUEs, respectively, at each sampling site.

Submerged vegetation cover (0–100%) was assessed by average value at each sampling site. Submerged vegetation volume was classified as an ordinate categorical variable from 0 (low density of meadows) to 5 (high density of meadows). We classified substrate *sensu* Bain (1999) [mud (1), sand (2), gravel (3), pebble (4) and boulder (5)] and assessed the SS (average at each sampling site) and SH (standard deviation at each sampling site).

**Statistical analyses**

The condition of *S. pavo* juveniles was indexed by residuals obtained from the least square regression of TM and TL of all captured individuals (log-transformed data) (Sutton et al., 2000). This residual index (Kr) provides an alternative to the more traditional condition indices, e.g. relative condition factor and Fulton's condition factor, and removes body length effects. The mean condition for *S. pavo* juveniles at each sampling site was determined from the average Kr of individuals at each sampling site. To avoid negative values, the variables were previously multiplied by 10<sup>3</sup>, a procedure considered suitable when variables range from 0 to 1 (García-Berthou and Moreno-Amich, 1993). The existence of significant differences between sampling sites was verified by non-parametric Kruskal–Wallis ANOVA analysis.

A stepwise multiple regression analysis was performed to determine the amount of variation in fish condition (mean Kr value at each sampling site) associated with environmental variables (mean values at each sampling site). This regression procedure firsts selects the most correlated independent variable, and then removes the variance in the dependent variable. It then selects the second independent variable which most correlates with the remaining variance in the dependent variable, and so on until selection of an additional independent does not increase the r<sup>2</sup> by a significant amount (P ≤ 0.05).

The colinearity between environmental variables in the regression model was tested using the Tolerance Index (TI) (Visauta-Vinacia, 1997). Bivariate relationships between environmental variables were also analysed using Pearson's correlation.

Statistical analyses were performed with the SPSS® (SPSS Inc., Chicago, IL, USA) software package and a significance level of P ≤ 0.05 was accepted.

**Table 2**  
Abundance (number of individuals/100 m<sup>2</sup>) and biomass (g 100 m<sup>-2</sup>) (in brackets) of captured species at each sampling site, total fish abundance and biomass at each sampling site and total abundance and biomass for each species

Species	Sampling site													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
<i>Aphanius iberus</i>	6.07 (10.17)	6.04 (2.83)	16.46 (11.94)	5.42 (4.86)	0.52 (0.14)	0.11 (0.02)	36.46 (7.09)	50.52 (8.22)	9.58 (3.36)	10.16 (2.18)	3.13 (1.04)	2.61 (0.44)	5.00 (0.64)	118.07 (23.14)
<i>Atherina boyeri</i>	97.94 (17.04)	81.46 (19.60)	170.21 (23.78)	38.44 (8.99)	5.42 (4.86)	1.67 (1.50)	7.29 (6.68)	20.31 (17.44)	28.96 (21.18)	21.72 (5.39)	26.77 (11.48)	49.17 (18.39)	108.54 (27.84)	303.31 (143.98)
<i>Pomatoschistus</i> sp.*	0.11 (0.31)	0.07 (0.11)	0.14 (1.42)	0.42 (0.96)	28.86 (19.39)	10.42 (1.86)	19.06 (9.46)	41.36 (13.54)	30.42 (9.59)	71.56 (21.53)	50.63 (20.72)	8.64 (2.38)	4.23 (0.42)	312.21 (115.39)
<i>Liza ramada</i>	—	—	—	—	—	—	—	0.31 (0.63)	—	—	—	—	—	0.63 (0.67)
<i>Liza saliens</i>	2.49 (1.64)	0.14 (1.42)	0.42 (0.96)	0.42 (0.96)	28.86 (19.39)	10.42 (1.86)	19.06 (9.46)	41.36 (13.54)	30.42 (9.59)	71.56 (21.53)	50.63 (20.72)	8.64 (2.38)	4.23 (0.42)	312.21 (115.39)
<i>Mugil cephalus</i>	—	—	—	—	—	—	—	0.31 (0.63)	—	—	—	—	—	0.63 (0.67)
<i>Chelon labrosus</i>	0.76 (0.64)	—	—	—	0.21 (0.14)	—	0.31 (0.04)	0.52 (0.68)	—	—	—	—	—	1.49 (1.46)
<i>Lipophrys dalmatinus</i> *	0.44 (0.16)	0.63 (0.21)	0.11 (0.04)	0.11 (0.04)	0.73 (0.39)	0.21 (0.12)	0.11 (0.08)	0.11 (0.08)	0.11 (0.14)	0.11 (0.14)	0.21 (0.02)	—	0.94 (0.19)	3.77 (1.54)
<i>Salaria pavo</i>	4.23 (2.73)	1.25 (1.92)	4.06 (2.28)	4.06 (2.28)	18.13 (11.49)	1.67 (0.99)	5.63 (3.96)	6.14 (4.54)	28.02 (14.88)	27.81 (9.71)	38.44 (28.61)	7.50 (3.75)	3.23 (4.95)	147.67 (97.04)
<i>Diplodus sargus sargus</i> *	0.11 (0.05)	0.28 (0.14)	—	—	1.25 (1.03)	0.90 (0.31)	0.21 (0.04)	—	—	—	—	—	0.11 (0.03)	2.85 (1.60)
<i>Dicentrarchus punctatus</i>	0.54 (0.81)	—	—	—	—	—	—	0.11 (0.79)	—	—	—	—	0.11 (0.63)	0.21 (1.42)
<i>Syngnathus typhle</i>	18.74 (4.44)	6.94 (1.23)	40.63 (6.64)	7.39 (1.18)	7.39 (1.18)	2.15 (0.57)	3.13 (0.70)	14.69 (0.36)	10.63 (2.69)	4.69 (1.66)	1.25 (0.42)	—	0.11 (0.14)	1.07 (1.50)
<i>Syngnathus abaster</i>	0.11 (0.11)	0.07 (0.01)	0.31 (0.17)	0.31 (0.17)	—	—	—	—	0.21 (0.13)	—	—	—	—	0.80 (0.46)
<i>Hippocampus guttulatus</i>	0.33 (0.25)	4.73 (2.92)	5.21 (4.08)	5.21 (4.08)	14.27 (9.8)	0.69 (0.65)	0.73 (1.05)	1.14 (2.98)	0.21 (0.30)	0.47 (0.49)	—	—	23.44 (4.00)	136.27 (24.34)
<i>Gobius cobitis</i> *	0.11 (1.11)	0.07 (0.04)	0.21 (0.25)	0.21 (0.25)	—	—	—	—	0.21 (0.33)	—	—	—	—	0.80 (0.46)
<i>Gobius niger</i> *	0.11 (1.11)	0.07 (0.04)	0.21 (0.25)	0.21 (0.25)	—	—	—	—	0.21 (0.33)	—	—	—	—	0.80 (0.46)
<i>Gobius paganellus</i> *	1.52 (1.44)	0.21 (0.20)	2.29 (1.69)	2.29 (1.69)	—	—	—	—	—	—	—	—	—	32.46 (32.86)
<i>Callionymus pusillus</i> *	0.22 (0.22)	0.07 (0.01)	0.63 (1.89)	0.63 (1.89)	—	—	—	—	—	—	—	—	—	0.94 (1.99)
<i>Symphodus cinereus</i> *	—	—	—	—	—	—	—	—	—	—	—	—	—	3.03 (2.19)
<i>Trachinotus ovatus</i>	133.69 (41.19)	102.14 (30.63)	240.73 (54.01)	115.21 (57.41)	90.56 (14.73)	91.04 (33.91)	116.36 (35.18)	188.13 (64.64)	158.23 (38.49)	161.25 (45.57)	128.96 (63.63)	153.02 (34.80)	188.65 (56.11)	1867.94 (590.29)
<b>Total</b>														

\*Benthic fish species.

## Results

The fish community structure varied across the 13 sampling sites. Of the 21 taxa captured, *Pomatoschistus* sp. (45.5% of total captures), *Liza saliens* (17.9%) and *Atherina boyeri* (17.4%) were the most abundant species. In turn, the dominant species in biomass terms were *A. boyeri* (24.25% of total biomass), *Pomatoschistus* sp. (21.7%) and *L. saliens* (19.4%). *S. pavo* accounted for 8.5% of the total abundance and 16.3% of the total biomass (Table 2).

Benthic fish species considered as potential competitors due to their benthic and trophic habits (Quignard and Pras, 1986; Dumay et al., 2004) represented 48.0% of the total abundance and 29.6% of the total biomass.

Fish condition data (mean Kr values at each sampling site) are presented in Table 3. Kruskal–Wallis ANOVA analysis showed significant differences in fish condition between sampling sites ( $\chi^2 = 166.05$ ;  $P < 0.0005$ ). Casablanca (sampling site 11) showed the lowest fish condition value, and Los Aliseos (sampling site 3) showed the highest value.

A stepwise multiple regression model indicated that water depth ( $P < 0.005$ ) and *S. pavo* biomass ( $P < 0.05$ ) accounted for most of the variations between sampling sites (59.9%) of Kr (Table 4), showing a negative effect in the condition of *S. pavo* juveniles. The TI value was 0.84, with no colinearity between environmental variables included in the regression model.

Bivariate relationships between Kr and environmental variables, and between the different environmental variables, are presented in Table 5. Of note is the positive and significant relationship between water depth and both the *S. pavo* biomass/abundance ratio and size of larger *S. pavo*.

Table 3

Mean condition (Kr  $\pm$  95% CL) for *Salaria pavo* juveniles at each sampling site obtained from standard residuals of the least square regression of total mass and total length of all captured individuals (log-transformed data) and mean TL (TL  $\pm$  95% CL) for *S. pavo* juveniles at each sampling site

Sampling site	n	Kr $\pm$ 95% CL	TL $\pm$ 95% CL
1 (Tomás Maestre)	30	-0.04 $\pm$ 0.40	2.7 $\pm$ 0.2
2 (Las Brisas)	21	-0.59 $\pm$ 0.62	2.9 $\pm$ 0.4
3 (Los Aliseos)	24	0.38 $\pm$ 1.17	3.1 $\pm$ 0.2
4 (Isla del Ciervo)	148	0.16 $\pm$ 0.32	3.3 $\pm$ 0.1
5 (Playa Paraíso)	23	-0.24 $\pm$ 0.35	2.7 $\pm$ 0.2
6 (Punta del Plome)	27	-0.51 $\pm$ 0.26	3.2 $\pm$ 0.2
7 (Los Nietos)	69	0.02 $\pm$ 0.29	3.6 $\pm$ 0.1
8 (Los Urrutias)	25	0.23 $\pm$ 1.19	3.5 $\pm$ 0.2
9 (Los Alcázares)	26	0.37 $\pm$ 0.74	3.5 $\pm$ 0.2
10 (La Hita)	120	-0.02 $\pm$ 0.52	2.9 $\pm$ 0.1
11 (Casablanca)	31	-0.67 $\pm$ 0.24	3.5 $\pm$ 0.2
12 (Villa Nanitos)	20	-0.13 $\pm$ 0.52	3.8 $\pm$ 0.4
13 (La Calcetera)	20	-0.33 $\pm$ 0.37	3.4 $\pm$ 0.5

Table 4

Stepwise multiple regression models used to predict condition (Kr) of *Salaria pavo* juveniles from environmental variables

Environmental variables	Regression equations	Adjusted $r^2$	F	d.f.	P
Model 1					
Water depth (cm)	Kr = 1.069-0.627 (water depth)	0.338	7.128	1, 11	<0.05
Model 2					
Water depth (cm)	Kr = 1.695-0.856 (water depth)	0.599	9.977	2, 10	<0.005
<i>S. pavo</i> biomass (BPUEs)	-0.570 ( <i>S. pavo</i> biomass)				

$r^2$ , proportion of variation explained by the regression models; P, probability levels of the regression models.

## Discussion

Our results showed that the somatic condition of *S. pavo* juveniles differed among sampling sites. Any differences in Kr were probably caused by differences in habitat conditions. Generally, fish condition varies seasonally due to many factors, including reproductive behaviour and gonadal development (Wootton, 1998). The fact that the sampling period was short (2 weeks) and that the study focused on juvenile specimens (TL < 4.5 cm), ensured that the differences in Kr were not related to seasonal variations on somatic condition.

In our site level analysis of the habitat-fish condition relationship, water depth and *S. pavo* biomass (significant variables in the multiple-regression analyses) were the ecological variables that best correlated with *S. pavo* juvenile condition. Sampling sites with higher water depth and with higher values of *S. pavo* biomass (Las Brisas, Punta del Plome and Casablanca) provided lower juvenile fish condition values.

Competition between fish can be an influential factor in fitness, growth, reproduction and survival. Individuals of the same species within the same population compete for similar resources and are potentially intense competitors (Wootton, 1998).

Intraspecific competition for food resources increases with increasing densities of individuals (Heath, 1992). The juveniles of some fish species suffer a decrease in somatic condition as the density of conspecifics increases (Tupper and Boutilier, 1995). Cowan et al. (2000) showed that, during juvenile stages, a reduction in prey resources due to high population densities is an important factor that reduces cohort growth. In the sampling sites which showed the highest *S. pavo* biomass values (which are related with high population densities), competition among juvenile fish for empty refuges and/or food resources was particularly strong. Indeed, the sampling sites present a relatively low substrate granulometry (mud-sand), thus agonistic behaviour and competition for refuge was almost certainly higher (Faria et al., 1998). In addition, Faria and Almada (2001) pointed out that intraspecific competition in two blenny species (*Lipophrys pholis* and *Coryphoblennius galerita*) was stronger than interspecific competition due to differences in the microhabitat use of each species.

In another context, the competitive superiority of larger individuals may reduce the availability of resources for smaller conspecifics, with the result that the dominant fishes show a higher condition value than subordinate fish (Adams et al., 1998; Sloman et al., 2001). In blennies, the dominant individuals of *Lipophrys pholis* have priority over subordinate fish for access to refuges (Gibson, 1968). In addition, agonistic behaviour is common between larger individuals of blenny (e.g. territorial behaviour, competition for refuge and male-male competition for nests, and parental care) (Faria et al., 1998; Gonçalves and Almada, 1998).

Table 5  
Pearson's correlation coefficients for comparisons between Kr and environmental variables

Environmental variables	Kr	Size of larger <i>S. pavo</i> (TL)	Fish species richness	<i>S. pavo</i> abundance (CPUEs)	Fish richness	<i>S. pavo</i> abundance (CPUEs)	<i>S. pavo</i> biomass (BPUes)	<i>S. pavo</i> B/A ratio	<i>S. pavo</i> biomass (BPUes)	<i>S. pavo</i> B/A ratio	Benthic fish abundance (CPUEs)	Benthic fish biomass (BPUes)	Benthic fish B/A ratio	Total fish abundance (CPUEs)	Total fish biomass (BPUes)	Total fish B/A ratio	Water temperature (°C)	Salinity (%)	Vegetation cover (%)	Vegetation volume	Depth (cm)	SS
Size of larger <i>S. pavo</i> (TL)	0.38																					
Fish species richness	0.11	0.52																				
<i>S. pavo</i> abundance (CPUEs)	0.02	0.57	-0.69*																			
<i>S. pavo</i> biomass (BPUes)	-0.23	0.40	-0.68*	0.91*																		
<i>S. pavo</i> B/A ratio	-0.50	0.77*	0.21	-0.35																		
Benthic fish abundance (CPUEs)	0.33	0.43	0.55	-0.53																		
Benthic fish biomass (BPUes)	0.27	0.46	0.65*	-0.57*																		
Benthic fish B/A ratio	0.03	0.08	0.23	-0.25																		
Total fish abundance (CPUEs)	0.57*	-0.35	0.04	0.05																		
Total fish biomass (BPUes)	0.36	-0.50	-0.21	0.53																		
Total fish B/A ratio	-0.12	-0.18	-0.32	0.58*																		
Water temperature (°C)	-0.01	-0.15	-0.48	-0.01																		
Salinity	-0.08	0.21	0.05	-0.08																		
Vegetation cover (%)	-0.19	-0.60*	-0.42	-0.19																		
Vegetation volume	-0.28	-0.54	-0.40	-0.28																		
Depth (cm)	-0.63*	0.69*	0.38	-0.62*																		
SS	-0.23	0.83*	0.47	-0.77*																		
SH	-0.14	0.45	-0.16	-0.11																		

CPUEs, catch per unit effort; BPUes, biomass per unit effort; SS, substrate size; SH, substrate heterogeneity; TL, total length.  
\*Significance level  $P < 0.05$ .

In our study, sampling sites with higher water depth presented a higher *S. pavo* biomass/abundance ratio and larger *S. pavo* individuals (TL > 4.5 cm) (Tables 1 and 5). This situation was related to the presence in these deeper sampling sites of adult and dominant fishes, which presumably monopolized refuges and food resources. In addition, because the sampling period coincided with the breeding season, the larger *S. pavo* fish showed territorial behaviour and defended small territories around the nests against intruders (whether of the same or of different species) (Gonçalves and Almada, 1998; Gonçalves et al., 2005). Consequently, adult breeding fish could produce an important level of stress in *S. pavo* juveniles, which would be reflected in lower somatic condition.

We found no relationship between the other variables of habitat structure (except depth) and juvenile fish condition, probably due to the number of sampling sites or perhaps because any relationship was clouded by the very complexity of the ecological interactions (e.g. a non-linear relationship between these variables). To a certain extent, this demonstrates the need for more investigation into the relationships between habitat characteristics, environmental variations and juvenile fish condition in the study area.

In conclusion, the somatic condition of the early phases of the life history of juvenile *S. pavo* in the shallow areas of the Mar Menor was directly affected by their biomass and depth, which are probably related to intraspecific competition, both intracohort and intercohort. Shallow areas with lower *S. pavo* biomass and a lower presence of adult breeding fish produced juvenile fishes with a better somatic condition because they were probably able to avoid competition for refuge and/or food resources with juvenile conspecifics and aggressive interactions with larger males.

#### Acknowledgements

The authors are grateful to Asunción Andreu, Andrés Egea and Pedro A. Miñano, members of the Department of Zoology of the University of Murcia, for help in field sampling; and Philip Thomas for the English revision. Part of this research was supported by the Environmental Service of the Autonomous Government of Murcia, Spain.

#### References

- Adams, C. E.; Huntingford, F. A.; Turnbull, J. F.; Beattie, C., 1998: Alternative competitive strategies and the cost of food acquisition in juvenile Atlantic salmon (*Salmo salar*). *Aquaculture* **167**, 17–26.
- Andreu-Soler, A.; Oliva-Paterna, F. J.; Fernández-Delgado, C.; Torralva, M., 2003: Age and growth of the sand smelt, *Atherina boyeri* (Risso 1810), in the Mar Menor coastal lagoon (SE Iberian Peninsula). *J. Appl. Ichthyol.* **19**, 202–208.
- Arias, A. M.; Drake, P., 1990: Estados alevines y juveniles de la ictiofauna en los caños de las salinas de la bahía de Cádiz. Instituto de Ciencias Marinas de Andalucía, CSIC, Junta de Andalucía, 163 pp.
- Bain, M. B., 1999: Substrate. In: Aquatic habitat assessment: common methods. M.B. Bain and N.J. Stevenson (Eds). American Fisheries Society, Bethesda, MD, pp. 95–100.
- Bergeron, J. P., 2000: Effect of strong winds on the nutritional condition of anchovy (*Engraulis encrasicolus* L.) larvae in the Bay of Biscay, Northeast Atlantic, as inferred from an early field application of the DNA/C index. *ICES J. Mar. Sci.* **57**, 249–255.
- Copp, G. H., 2003: Is fish condition correlated with water conductivity? *J. Fish Biol.* **63**, 263–266.
- Cowan, J. H., Jr; Rose, K. A.; DeVries, D. R., 2000: Is density-dependent growth in young-of-the-year fishes a question of critical weight? *Rev. Fish Biol. Fish.* **10**, 61–89.
- Dumay, O.; Tari, P. S.; Tomasini, J. A.; Mouillot, D., 2004: Functional groups of lagoon fish species in Languedoc Roussillon, southern France. *J. Fish Biol.* **64**, 970–983.
- Faria, C.; Almada, V., 2001: Microhabitat segregation in three rocky intertidal fish species in Portugal: does it reflect interspecific competition? *J. Fish Biol.* **58**, 145–159.
- Faria, C.; Almada, V.; Nunes, M. C., 1998: Patterns of agonistic behaviour, shelter occupation and habitat preference in juvenile *Lipophrys pholis*, *Coryphoblennius galerita* and *Gobius cobitis*. *J. Fish Biol.* **53**, 1263–1273.
- García-Berthou, E.; Moreno-Amich, R., 1993: Multivariate analysis of covariance in morphometric studies of the reproductive cycle. *Can. J. Fish Aquat. Sci.* **50**, 1394–1399.
- Gibson, R. N., 1968: The agonistic behaviour of juvenile *Blennius pholis* L. (Teleostei). *Behaviour* **30**, 192–217.
- Gonçalves, E. J.; Almada, V. C., 1997: Sex differences in resource utilization by the peacock blenny. *J. Fish Biol.* **51**, 624–633.
- Gonçalves, E. J.; Almada, V. C., 1998: A comparative study of territoriality in intertidal and subtidal blennioids (Teleostei, Blennioidei). *Environ. Biol. Fish.* **51**, 257–264.
- Gonçalves, D.; Matos, R.; Fagundes, T.; Oliveira, R., 2005: Bourgeois males of the peacock blenny, *Salarias pavo*, discriminate female mimics from females? *J. Fish Biol.* **111**, 559–572.
- Heath, M. R., 1992: Field investigations on the early life stages of marine fish. *Adv. Mar. Biol.* **28**, 1–174.
- Hoey, A. S.; McCormick, M. I., 2004: Selective predation for low body condition at the larval-juvenile transition of a coral reef fish. *Oecologia* **139**, 23–29.
- Jakob, E. M.; Marshall, S. D.; Uetz, G. W., 1996: Estimating fitness: a comparison of body condition indices. *Oikos* **77**, 61–67.
- Lloret, J.; Planes, S., 2003: Condition, feeding and reproductive potential of white seabream *Diplodus sargus* as indicators of habitat quality and the effect of reserve protection in the northwestern Mediterranean. *Mar. Ecol. Prog. Ser.* **248**, 197–208.
- Lloret, J.; Galzin, R.; Gil de Sola, L.; Souplet, A.; Demestre, M., 2005: Habitat related differences in lipid reserves of some exploited fish species in the north-western Mediterranean continental shelf. *J. Fish Biol.* **67**, 51–65.
- Morgan, M. J., 2004: The relationship between fish condition and the probability of being mature in American plaice (*Hippoglossoides platessoides*). *ICES J. Mar. Sci.* **61**, 64–70.
- Murphy, B. R.; Brown, M. L.; Springer, T. A., 1990: Evaluation of the relative weight (Wr) Index, with new applications to walleye. *North Am. J. Fish. Manage.* **10**, 85–97.
- Oliva-Paterna, F. J.; Vila-Gisbert, A.; Torralva, M., 2003: Condition of *Barbus sclateri* from semiarid aquatic systems: effects of habitat quality disturbances. *J. Fish Biol.* **63**, 1–11.
- Pérez-Ruzafa, A.; Navarro, S.; Barba, A.; Marcos, C.; Cámara, M. A.; Salas, F.; Gutiérrez, J. M., 2000: Presence of pesticides throughout trophic compartments of the food web in the Mar Menor lagoon (SE Spain). *Mar. Poll. Bull.* **40**, 140–151.
- Pérez-Ruzafa, A.; Gilabert, J.; Gutiérrez, J. M.; Fernández, A. I.; Marcos, C.; Sabah, S., 2002: Evidence of a planktonic food web response to changes in nutrient input dynamics in the Mar Menor coastal lagoon, Spain. *Hydrobiologia* **475/476**, 359–369.
- Pérez-Ruzafa, A.; Quispe-Becerra, J. I.; García-Charton, J. A.; Marcos, C., 2004: Composition, structure and distribution of the ichthyoplankton in a Mediterranean coastal lagoon. *J. Fish Biol.* **64**, 202–218.
- Quignard, J. P.; Pras, A., 1986: Labridae. In: Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 3. P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese (Eds). UNESCO, Paris, pp. 919–942.
- Rätz, H. J.; Lloret, J., 2003: Variation in fish condition between Atlantic cod (*Gadus morhua*) stocks, the effect on their productivity and management implications. *Fish. Res.* **60**, 369–380.
- Slovan, K. A.; Taylor, A. C.; Metcalfe, N. B.; Gilmour, K. M., 2001: Effects of an environmental perturbation on the social behaviour and physiological function of brown trout. *Anim. Behav.* **61**, 325–333.
- Sutton, S. G.; Bult, T. P.; Haedrich, R. L., 2000: Relationships among fat weight, body weight, water weight and condition factors in wild salmon parr. *Trans. Am. Fish. Soc.* **129**, 527–538.
- Tupper, M.; Boutilier, R. G., 1995: Effects of conspecific density on settlement, growth and post-settlement survival of a temperate reef fish. *J. Exp. Mar. Biol. Ecol.* **191**, 209–222.
- Visauta-Vinacua, B., 1997: Análisis estadístico con SPSS para Windows. McGraw-Hill, Madrid, 304 pp.

- Whitehead, P. J. P.; Bauchot, M. L.; Hureau, J. C.; Nielsen, J.; Tortonese, E., 1986: Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris, 1473 pp.
- Wootton, R. J., 1998: Ecology of teleost fishes. Kluwer Academic Publishers, Dordrecht, 386 pp.
- Zander, C. D., 1986: Blennidae. In: Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 3. P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese (Eds). UNESCO, Paris, pp. 1096–1112.
- Author's address:** David Verdiell-Cubedo, Department of Zoology, University of Murcia, E-30100 Murcia, Spain.  
E-mail: verdiell@um.es