Environ Biol Fish (2015) 98:121–133
DOI 10.1007/s10641-014-0241-z

Abundance and biomass of the parrotfish *Sparisoma cretense* in seagrass meadows: temporal and spatial differences between seagrass interiors and seagrass adjacent to reefs

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Received: 14 March 2013 / Accepted: 24 January 2014 / Published online: 11 February 2014

Abstract Seagrass habitats are relevant for numerous nearshore fish species, particularly as nursery grounds. Seagrass meadows are often interspersed with other habitats, what can alter the distribution and abundance of seagrass ichthyofauna. This research aimed to determine whether there is a change in the abundance and biomass of the parrotfish, *Sparisoma cretense*, in seagrass meadows (*Cymodocea nodosa*) with varying proximity from rocky reefs, specifically seagrass interiors (>200 m away from reefs) *vs.* seagrass adjacent to reefs (<10 m away). Sampling was undertaken using a seine net and underwater visual census through an entire annual cycle. Adults were predominantly observed in seagrass adjacent to reefs, which seem to be restricted to incursions of large-sized parrotfish from adjacent reefs. Juvenile abundance did not significantly differ between seagrass interiors and seagrass adjacent to reefs; however, juvenile biomass was greater in seagrass meadows adjacent to reefs compared to those far away from reefs. This pattern was consistent through times for both sampling techniques. These results suggest a transition of juvenile parrotfish from seagrass interiors to seagrass near reefs, so juveniles are located in the vicinity of their adult habitat, i.e. rocky reefs.

Keywords Reefs · Ecotones · Underwater visual counts · Seine nets · Canary Islands

Introduction

Seagrass landscapes support a large number of invertebrate and fish species by providing food and shelter (Beck et al. 2001). In particular, seagrass meadows have been routinely viewed as key 'nursery' grounds for juveniles of many fish species, including commercially exploited species (Pollard 1984; Gillanders 2006). This results from the large structural complexity (Gullström et al. 2008) and abundance of trophic resources (Bell and Pollard 1989) provided by seagrasses. The presence of fishes in seagrasses, however, may fluctuate through time scales ranging from days to years, according to the specific peculiarities of species' life cycles, including migrations among distinct habitats (Gillanders 2002; Elsdon and Gillanders 2003). For example, *Diplodus annularis* is associated with seagrasses during its complete life cycle (Brito et al. 2002), while *Spondyliosoma cantharus* use seagrasses as a nursery habitat (Espino et al. 2011a, b), occupying rocky reefs and sand-rocky habitats when adults (Lorenzo and González 1997). Seagrass meadows are frequently interspersed with other habitats, such as rocky-reefs, coral reefs, mangroves, and unvegetated sediments (Wernberg et al. 2006; Valentine et al. 2008; Tuya et al. 2010). At a landscape

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scale, the spatial arrangement and size of these habitats can exert a strong influence on movements of many organisms, affecting patterns in the distribution and abundance of species, e.g. invertebrates and fishes (Tuya et al. 2010, 2011). Several studies have focused on the influence of proximity from a range of habitats on the abundance and structure of fish assemblages inhabiting seagrass meadows, e.g. mangroves-seagrasses (Jelbart et al. 2007), seagrasses-coral reefs (Dorenbosch et al. 2005; Valentine et al. 2008), and mangroves-seagrasses-coral reefs (Nagelkerken et al. 2000; Cocheret de la Morinière et al. 2002; Aguilar-Perera and Appeldoorn 2008). For example, *Scarus taeniopterus* and *S. iserti* are species that use seagrasses as nursery habitats and experience a subsequent migration to coral reefs as adults. However, both species showed different migration pace patterns, abruptly for *S. taeniopterus* and more smooth for *S. iserti* (Cocheret de la Morinière et al. 2002). The effect of proximity from adjacent habitats on patterns of abundance of seagrass fishes may also change according to the fish body size, reflecting changes in species' life cycles. For example, mangroves and seagrasses are daytime feeding habitats for a coral reef fish, the French grunt *Haemulon flavolineatum*, but exclusively for individuals within a particular body size (Verweij et al. 2006).

Different sampling techniques are used to sample fishes in coastal habitats, seagrass beds in particular. Some of the most widely used are capture by fishing gears and visual count methods. Trawls with seine nets are particularly adequate for small-sized individuals (Guest et al. 2003) that are typically overlooked by visual techniques. Underwater visual censuses, on the other hand, are predominantly recommended for large-sized fishes in clear-water habitats (Edgar et al. 2001), because they often escape from trawls. Importantly, different techniques can result in different outcomes when testing for models of spatial and temporal variability in the abundance and biomass of organisms. For example, Harmelin-Vivien and Francour (1992) found that underwater visual census recorded more abundance and biomass than bottom trawls, but trawls recorded more fish species, when studying fish assemblages associated with *Posidonia oceanica* meadows. As a result, many authors have recommended the combination of different, but complementary sampling methods to accurately study fish assemblages inhabiting seagrass meadows (Harmelin-Vivien and Francour 1992; Bobsien and Brandelberger 2006).

The parrotfish *Sparisoma cretense* (Linnaeus, 1758) is one of the few temperate species of the Scaridae family (Bernardi et al. 2000). This species is distributed in the eastern coasts of the Mediterranean Sea, the Macaronesian archipelagos (Azores, Madeira, Canaries and Cape Verde) and the northwest coast of Africa (González 1993). It is a necto-benthic species, inhabiting rocky bottoms and seagrass beds on shallow waters to about 50 m depth (Guidetti and Boero 2002). *Sparisoma cretense* is a daytime feeder, scraping algae, seagrasses and small invertebrates from the substrate with its fused, beak-like jaws. In the Canarian Archipelago, *S. cretense* is a demersal species, usually observed inhabiting rocky bottoms, especially vegetated reefs, but also in mixed rocky-sandy bottoms, while juveniles can be found in seagrass beds (Mena et al. 1993; Brito et al. 2002; Tuya et al. 2006a; Espino et al. 2011a, b). This species is highly prized for both local recreational and commercial fisheries (Bortone et al. 1991; Bas et al. 1995). This study aimed to: a) determine whether proximity from rocky reefs, here seagrass interiors *versus* seagrass adjacent to reefs, affects the abundance and biomass of *S. cretense* inhabiting seagrass meadows; b) determine the temporal and spatial consistency of these patterns via two different sampling techniques, underwater visual census *vs.* seine nets; and c) assess whether patterns might be altered by the use of different sampling techniques.

Methods

Study area and sampling design

Gran Canaria is an almost circular island (~50 km in diameter) in the middle of the Canarian archipelago, which is located in the north-western African coast. The oceanographic conditions are characterized by the Canary current that flows to the southwest and dominant trade winds that blows from the northeast. Sea surface temperature typically ranges from 18 °C in winter to 24 °C in summer (Navarro-Pérez and Barton 2001). For the purpose of this work, we selected three seagrass meadows constituted by the seagrass *Cymodocea nodosa*; two meadows are located in the southeast, ca. 2 km apart, while the other meadow is located in the southwest part of the island, ca. 50 km apart (Fig. 1). The area covered by these seagrass meadows ranges between 98,417 and 243,580 m^2 at 6–15 m of depth

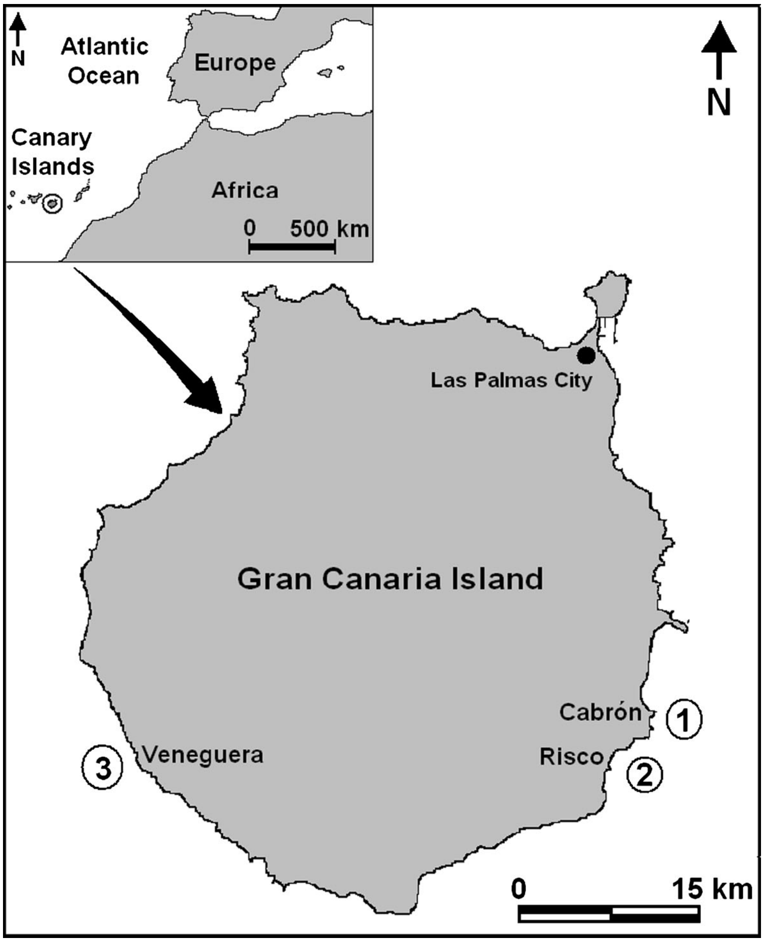

Fig. 1 Overview of the study area, including the island of Gran Canaria (27°58′N, 15° 36′W) and the location of the three seagrass meadows

(Ministerio de Medio Ambiente 2002). Each meadow was visited four times through an entire annual cycle: February 2011, May 2011, August 2011 and November 2011. Dates were separated to encompass conditions encountered throughout an entire year. At each meadow two sites, separated by 100 s m, were randomly selected. At each site, fish were sampled at to distances: seagrass adjacent to reefs (ca. <10 m away from reefs) and in seagrass interiors (>200 m away from reefs). Other habitats that have been shown to be relevant during some phases of the life cycle of other parrotfish species are not present in the study region.

Fish and seagrass sampling

Parrotfish were sampled using two techniques: underwater visual censuses (hereafter UVC) and seine nets (hereafter SN). At each site and distance, six replicated 25 m long and 4 m wide transects were firstly laid out randomly during daylight hours, typically between 10:00 and 12:00. The transects were made by two SCUBA divers (3 each diver) simultaneously, surveying different areas to avoid fish to be counted twice. The abundance (total number of individuals) and size (to the nearest 1 cm of total length) of all individuals of *S. cretense* were recorded on waterproof paper. In the study area, this procedure provides optimal precision and accuracy to account for the abundance and size-structure of both rocky-reef and seagrass fishes (Tuya et al. 2004, 2006a), *S. cretense* in particular (Tuya et al. 2006b). Secondly, three replicated, 25 m long and 4 m wide, bottom trawls were carried out using a seine net, in approximately the same transect lines where the UVC were previously made. This technique has been successfully applied to study small fish inhabiting seagrass beds in the study area, exclusively capturing small-sized (juvenile) parrotfish (Espino et al. 2011a, b). Thirdly, three descriptors of the seagrass physical structure at each transect line were registered: (1) shoot density (by counting seagrass shoots in $n=6$, 25×25 cm, quadrats that were deployed in the middle of each transect line), (2) leaf length (by measuring the average leaf length in 20 shoots randomly selected within each quadrat) and (3) seagrass coverage during UVC performance (by registering the distance under a 1 cm×25 m flexible line transect covered by the seagrass *C. nodosa* to the nearest cm and subsequent calculation of % coverage, n=6).

All fish captured by the SNs were preserved in a 10 % of formalin/seawater solution and carried to the laboratory, where the total length (TL±1 mm) and weight (W±0.001 g) was annotated. Biomasses for fish counted through UVCs were calculated using an available length–weight relationship for the Canarian archipelago ($W=0.0135\ L^{3.0222}$, González 1991), when total length was ≥20 cm. Biomasses of fish with a TL<20 cm were calculated using an unpublished length–weight relationship ($W=0.0155\ L^{3.0158}$, $R^2=0.9916$, $n=312$) from our own data. Individuals were classified as adults (TL≥20 cm) and juveniles (TL<20 cm) using the first maturity size for the study region (González 1991; González and Lozano 1992). This is pertinent, as adult and juvenile *S. cretense* have different movement capacity and degree of association with seagrasses, similar to other parrotfish species (Ogden and Zieman 1977; Hyndes et al. 2003; Maciá and Robinson 2005).

Statistical analysis

The three structural descriptors of seagrass structure (shoot density, leaf length and seagrass coverage) were analysed by means of 4-way ANOVA models to test if proximity from reefs affected seagrass structure. The model incorporated the factors: (1) 'Time' (fixed factor with four levels); (2) 'Meadow' (random factor with three levels and orthogonal to 'Time'); (3) 'Site' (random factor with two levels nested within 'Meadow' and 'Time'); and (4) 'Distance' (fixed factor with two levels and orthogonal to the previous factors). In particular, analyses focused on the main effects of 'Distance' and the interaction term between 'Distance' and 'Time', to unconfound patterns of parrotfish abundance and biomass with changes in seagrass structure with varying proximity from reefs. The abundance and biomass of adults and juveniles were analysed by means of 4-way ANCOVA models to test for differences among times, meadows, sites within meadows, and distance from reefs. The model followed the same criteria outlined before. The three seagrass structural descriptors were included as covariates to remove variation within the residual term, and so to increase the power to detect significant differences. Prior to the analyses, the Cochran's test was used to check for homogeneity of variances. Data from UVCs were Ln (X+1) transformed and rendered homogenous variances for adult biomass (C=0.0731, P>0.05), juvenile abundance (C=0.0947, P>0.05) and juvenile biomass (C=0.0421, P>0.05), but not for adult abundance (C=0.4324, P<0.01). In the latter case, the significance level was set at the 0.01, instead of the 0.05 level, as ANOVA is robust to heterogeneous variances for large, balanced, experiments (Underwood 1997). Abundance and biomass data from SNs were transformed to Ln (X+1) and rendered homogenous variances for both cases (Cochran's tests, C= 0.122 and C=0.1334, P>0.05, respectively). When appropriate, SNK *a-posteriori* multiple comparison tests were performed (Underwood 1997), particularly when either 'Time' or 'Distance' were involved as an interaction or as a main effect. The size structure of the parrotfish was compared between seagrass meadows adjacent to reefs and seagrass interiors through a χ^2.

Results

Patterns of abundance and biomass of *S. cretense* between seagrass interiors and seagrass adjacent to reefs were unconfounded by changes in seagrass structure with varying proximity from reefs: shoot density ('*D*', F=0.43, P=0.578; '*S* × *D*', F=0.47, P=0.713), leaf length ('*D*', F=0.13, P=0.751; '*S* × *D*', F=1.19, P=0.399) and seagrass coverage ('*D*', F=0.3, P=0.639; '*S* × *D*', F=0.36, P=0.786).

UVCs: abundance and biomass patterns with varying proximity from reefs

A total of 644 individuals were observed (20.03 % were adults and 79.97 % juveniles). Adult parrotfish were majorly (88.37 % of all adults individuals) observed in seagrass adjacent to reefs, especially at some sites of two meadows ('Cabrón' and 'Risco') (Fig. 2a–d). This resulted in a significant '*D* × *Si* (*T* × *M*)' interaction term for the abundance (P=0.007, Table 1) and biomass (P=0.003, Table 1) of adult parrotfish; this masked overall differences in adult abundance and biomass between seagrass interiors and seagrass adjacent to reefs through times ('*D*', '*T* × *D*', P>0.05, Table 1). Juvenile abundance and biomass also changed inconsistently

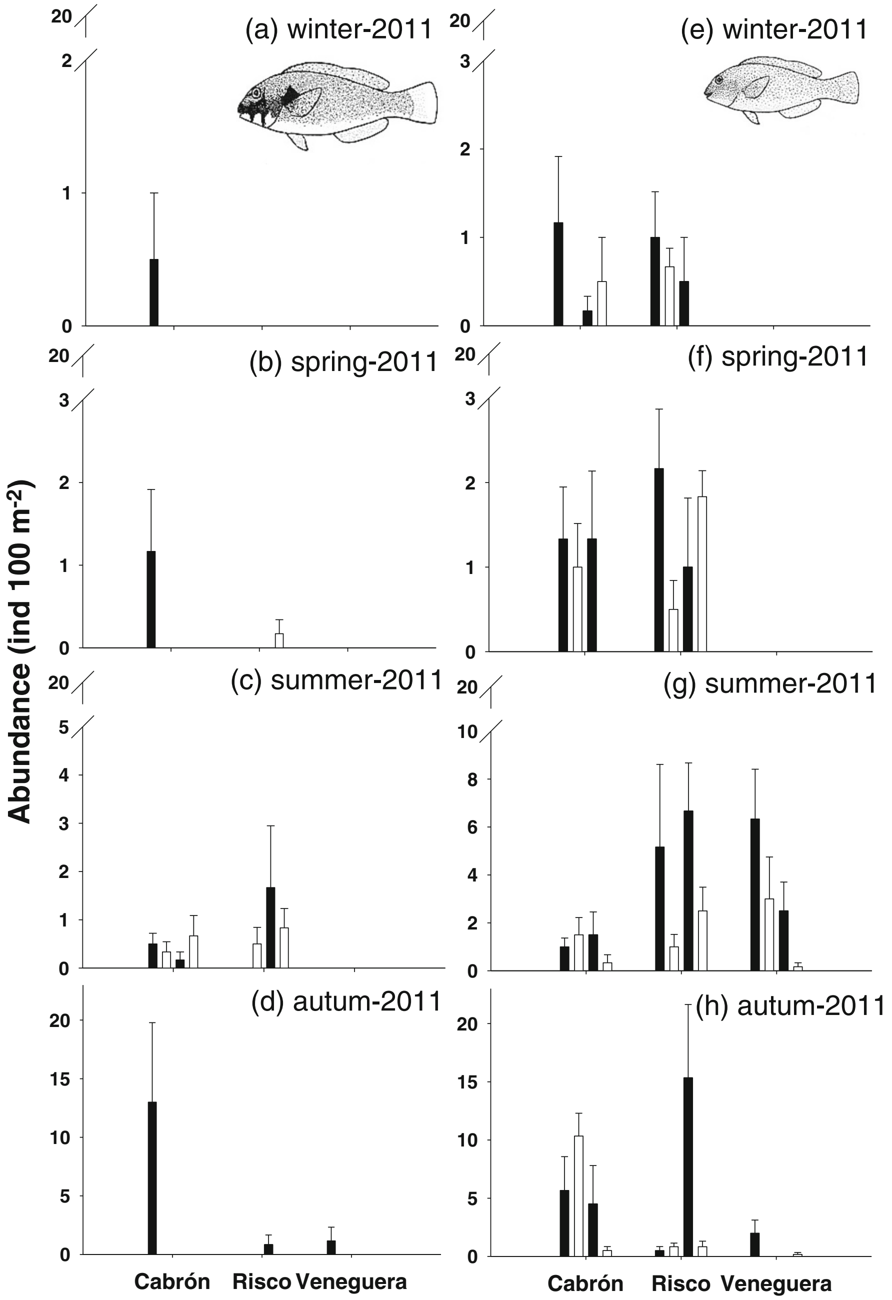

Fig. 2 Mean abundance of adult (**a**, **b**, **c**, **d**) and juvenile (**e**, **f**, **g**, **h**) parrotfish *Sparisoma cretense* recorded through UVCs (n=6), at seagrass interiors (*white bars*) and seagrass adjacent to reefs (*black bars*) at each of two sites within each seagrass meadow and time. *Errors bars* are standard errors of mean values

between seagrass adjacent and far away from reefs between sites within meadows and times (‘$D \times Si$ ($T \times M$)’, P=0.001 in both cases). Importantly, the biomass of juveniles overall differed between seagrass interiors and seagrass adjacent to reefs (‘D’, P=0.038, Table 1, Fig. 3e–h), independently of times (‘$T \times D$’, P>0.05, Table 1); indeed, juvenile biomass was 1.9 times larger at seagrass adjacent to reefs than in seagrass interiors (Fig. 3e–h). Juvenile abundance was 2.35 times larger at seagrass adjacent to reefs than in seagrass interiors (Fig. 2e–h); however, differences were marginally non-significant (‘D’, P=0.056, Table 1). Larger

Table 1 Results of the analysis of covariance (ANCOVA) testing the effects of 'Time' (fixed factor), 'Meadow' (random factor), 'Site' (random factor nested within times and meadows) and 'Distance' from reefs (fixed factor; orthogonal to the previous factors) on the abundance and biomass of adult and juvenile parrotfish *Sparisoma cretense* recorded through UVCs

Source of variation	DF	Adult abundance			Adult biomass			Juvenile abundance			Juvenile biomass		
		MS	*F*	*P*	MS	*F*	*P*	MS	*F*	*P*	MS	*F*	*P*
Covariates													
Shoot density	1	16.3540	22.2040	0.001	3081.6	34.5860	0.001	55.1350	26.1480	0.001	1261.2	27.3740	0.001
Leaf length	1	0.25653	0.44040	0.534	8.1454	0.11902	0.734	0.00216	0.00142	0.976	31.074	0.92808	0.327
Seagrass coverage	1	3.01000	2.92180	0.123	178.67	3.92080	0.075	5.98720	2.62700	0.138	313	6.41160	0.032
Time, *T*	3	0.36445	1.33980	0.374	44.816	1.02230	0.489	5.28200	1.61750	0.283	129.28	3.81760	0.095
Meadow, *M*	2	1.64690	2.91460	0.092	21.172	0.19241	0.820	3.40230	1.73790	0.232	71.765	1.65670	0.204
Site (*T* × *M*), *Si*	12	0.64947	2.24990	0.007	124.94	2.03980	0.014	2.31980	3.00200	0.001	51.139	2.88500	0.002
Distance, *D*	1	1.50600	0.69411	0.514	154.53	0.38092	0.653	5.92030	19.3310	0.056	79.437	22.6620	0.038
T × *M*	6	0.24071	0.37139	0.877	44.559	0.35804	0.919	3.30430	1.41300	0.269	33.177	0.64560	0.690
T × *D*	3	1.46150	4.11840	0.053	261.02	1.66160	0.264	0.66010	0.49246	0.667	10.812	0.51089	0.707
M × *D*	2	2.07960	3.15930	0.090	400.33	2.07170	0.177	0.29286	0.11797	0.908	3.3932	0.06226	0.935
D × *Si* (*T* × *M*)	12	0.65211	2.25900	0.007	192.91	3.14950	0.003	2.53140	3.27590	0.001	57.137	3.22350	0.001
T × *M* × *D*	6	0.34355	0.52389	0.773	153.83	0.78066	0.650	1.37130	0.53343	0.789	22.05	0.38260	0.892
Residual	237	0.28867			61.252			0.77274			17.725		

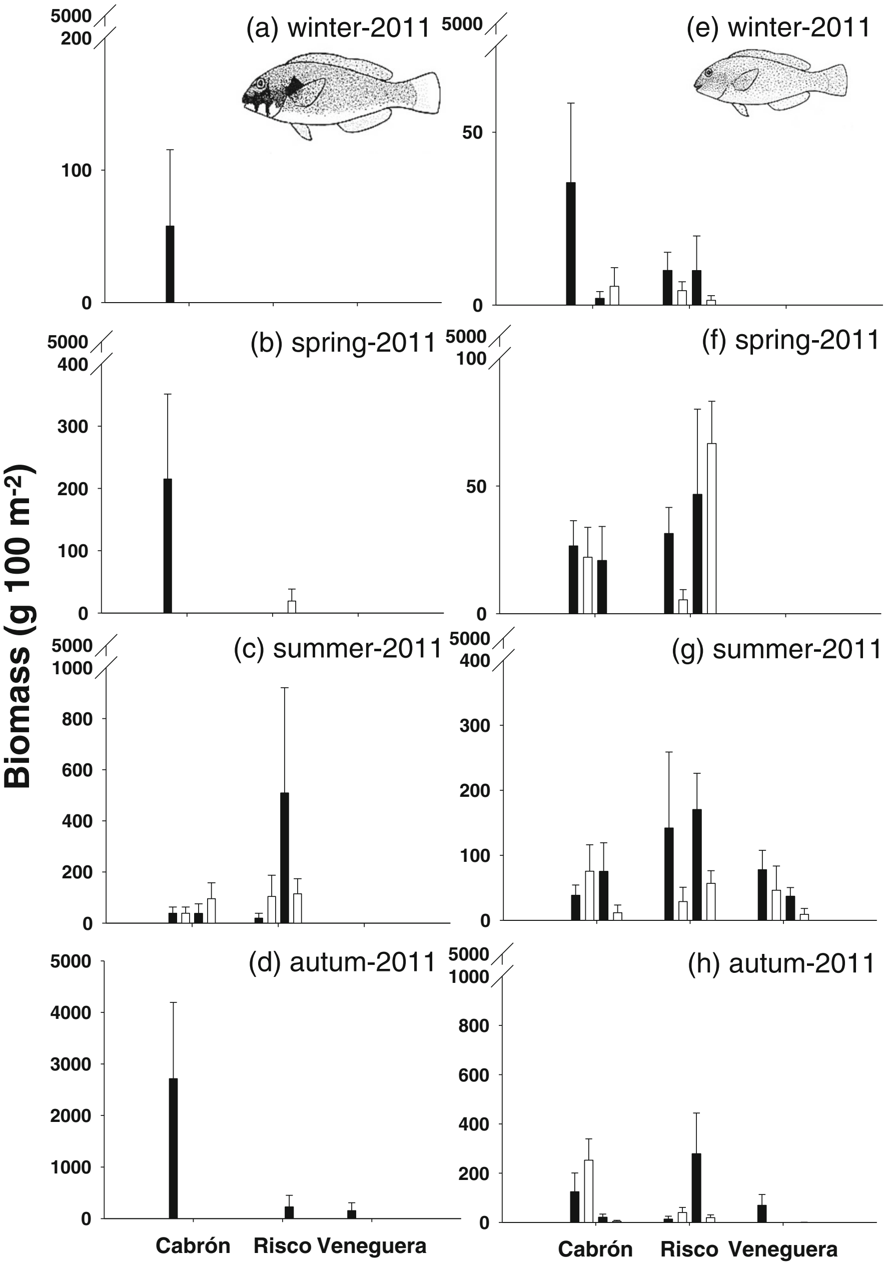

Fig. 3 Mean biomass of adult (**a**, **b**, **c**, **d**) and juvenile (**e**, **f**, **g**, **h**) parrotfish *Sparisoma cretense* recorded through UVCs (n=6), at seagrass interiors (*white bars*) and seagrass adjacent to reefs (*black bars*), at each of two sites within each seagrass meadow and time. *Errors bars* are standard errors of mean values

juvenile abundance and biomass at seagrass near reefs than seagrass interiors were consistent through times (‘$T \times D$’, P>0.05 for both juvenile abundances and biomasses, Table 1). The size structure of the juvenile parrotfish significantly differed between seagrass meadows near reefs and seagrass interiors (χ^2=17.18, d.f.=7, P=0.016) (Fig. 6a).

SNs: abundance and biomass patterns with varying proximity from reefs

A total of 312 individuals were collected; all were juveniles. Parrotfish abundance and biomass varied among times inconsistently from meadow to meadow (‘$T \times M$’, Table 2, P<0.1, SNK tests, Figs. 4 and 5). For

Table 2 Results of the analysis of covariance (ANCOVA) testing the effects of 'Time' (fixed factor), 'Meadow' (random factor), 'Site' (random factor nested within times and meadows) and 'Distance' from reefs (fixed factor; orthogonal to the previous factors) on the abundance and biomass of the parrotfish *Sparisoma cretense* recorded through SNs

Source of variation	DF	Abundance			Biomass		
		MS	*F*	*P*	MS	*F*	*P*
Covariates							
Shoot density	1	3.50210	1.10970	0.296	130.330	3.04450	0.094
Leaf length	1	2.44650	0.79442	0.370	13.8870	0.33671	0.577
Seagrass coverage	1	2.35450	0.46214	0.500	48.6210	0.73168	0.396
Time, T	3	10.2180	2.84780	0.133	121.590	2.94660	0.137
Meadow, M	2	11.9170	13.0610	0.002	152.720	10.2380	0.003
Site ($T \times M$), Si	12	0.99806	1.69440	0.081	16.4720	1.82080	0.053
Distance, D	1	0.00265	0.11153	0.854	25.7840	46.4870	0.021
$T \times M$	6	3.34190	3.29700	0.034	37.9320	2.27020	0.081
$T \times D$	3	0.34982	0.31952	0.804	16.6080	0.92069	0.486
$M \times D$	2	0.41403	0.61717	0.557	0.53464	0.12451	0.868
$D \times Si\ (T \times M)$	12	0.68231	1.15830	0.338	8.71270	0.96313	0.450
$T \times M \times D$	6	1.13730	1.60450	0.217	17.7000	1.95440	0.164
Residual	93	0.58905			9.07690		

example, parrotfish abundance and biomass did not vary among times for 'Cabrón', while the other two meadows had larger parrotfish abundance and biomass in summer (Figs. 4 and 5, Table 3). Parrotfish abundance did not overall differed with varying proximity from reefs ('D', $P=0.854$, Table 2, Fig. 4). However, a larger parrotfish biomass (1.86 times) was observed in seagrass adjacent to reefs than in seagrass interiors ('D', $P=0.021$, Table 2, Fig. 5). Differences in parrotfish abundance and biomass between distances away from reefs were consistent through times ('$T \times D$', $P>0.05$, Table 2). Juveniles in seagrass meadows near reefs had a larger mean total length that those in seagrass interiors (8.90± 0.27 and 7.12±0.26 cm; mean ± standard error, respectively) (Fig. 6b). In turn, the size structure of the parrotfish significantly differed between seagrass meadows near reefs and seagrass interiors ($\chi^2=46.78$, d.f.=7, $P<0.001$).

Discussion

Patterns of adult abundance and biomass with varying proximity from reefs

Despite UVCs did not detect consistent differences in the abundance and biomass of adult *S. cretense* between seagrass interiors and seagrass adjacent to reefs. This result was likely caused by the low number of registered adults. In any case, the majority (88.37 %) of adults were found in seagrasses juxtaposed with reefs. In the study region, *S. cretense* is particularly abundant on shallow rocky bottoms, predominantly on reefs covered by macroalgal canopies (Tuya et al. 2006b), while juveniles also occur on *C. nodosa* seagrass meadows (Mena et al. 1993; Brito et al. 2002; Tuya et al. 2006a; Espino et al. 2011a, b). Therefore, the presence of *S. cretense* adults in *C. nodosa* seagrass meadows seems to be restricted to incursions from adjacent reefs, most likely to feed. This is supported by, firstly, the presence of adult parrotfish inhabiting shallow-water rocky reefs in the study region (Tuya et al. 2006b). Secondly, a similar pattern has also been detected in the Mediterranean, where *S. cretense* is found on rocky reefs, feeding on macroalgae, yet occasional displacements towards seagrass meadows dominated by *Posidonia oceanica* can also occur to feed on seagrass epiphytes (Bernardi et al. 2000; Kalogirou et al. 2010). In tropical areas, distinct parrotfish species inhabit coral reefs; intermittent displacements of adults towards neighboring seagrasses are common to feed (Randall 1965; Ogden and Zieman 1977; Tribble 1981; Macintyre et al. 1987). This pattern is attributed to the inability of large-sized parrotfish (20–40 cm) to constantly use seagrass

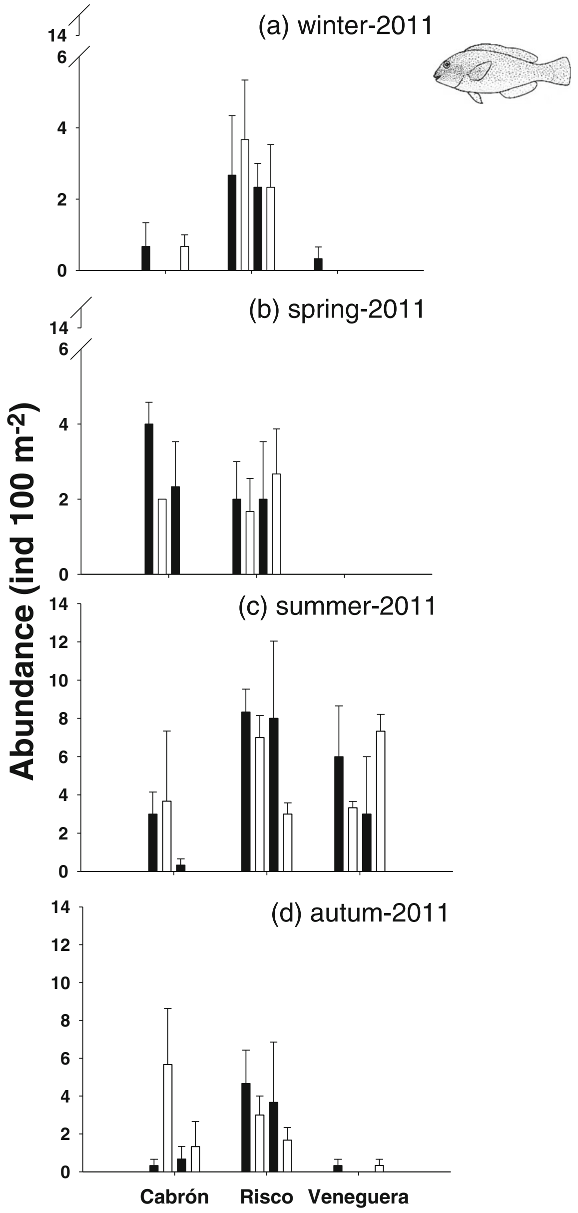

Fig. 4 Mean abundance of the parrotfish *Sparisoma cretense* at seagrass interiors (*white bars*) and seagrass adjacent to reefs (*black bars*), recorded through SNs (n=3), at each of two sites within each seagrass meadow and time. *Errors bars* are standard errors of mean values

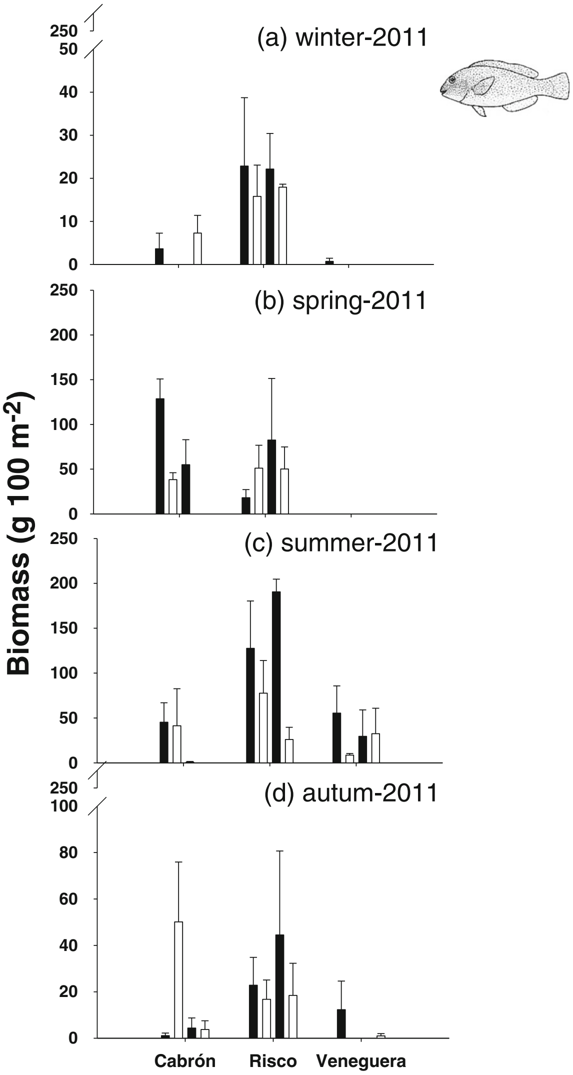

Fig. 5 Mean biomass of the parrotfish *Sparisoma cretense* at seagrass interiors (*white bars*) and seagrass adjacent to reefs (*black bars*), recorded through SNs (n=3), at each of two sites within each seagrass meadow and time. *Errors bars* are standard errors of mean values

canopies as refuges, while small-sized parrotfish (<15 cm) freely move across seagrass canopies (Ogden and Zieman 1977). The same outcome was identified when parrotfish grazing patterns were analyzed (Maciá and Robinson 2005). Adults did not show any consistent temporal pattern in their abundances and biomasses, as observed for individuals on rocky reefs (Tuya et al. 2006b). The low abundance of adult parrotfish somehow reinforces the notion of the large fishing pressure this species is suffering in Gran Canaria (Tuya et al. 2006b).

Adult abundance was larger at meadows 'Cabrón' and 'Risco', which are nearby to reefs covered by frondose macroalgal canopies at shallow water (e.g. *Cystoseira* spp. and *Sargassum* spp., mean coverage ± SE=85.56±16.67 %, Rodríguez et al. 2008), relative to 'Veneguera' meadow, which is juxtaposed to reefs lacking macroalgal canopies (Rodríguez et al. 2008). The

Table 3 Results of *a posteriori* tests for pairwise comparisons of juvenile *S. cretense* abundance and biomass captured through SNs between times for each meadow

Pairwise comparison	Cabrón	Risco	Veneguera
Abundance			
Winter *vs.* spring	n.s.	n.s.	n.s.
Winter *vs.* summer	n.s.	n.s.	Summer > winter P=(0.001)
Winter *vs.* autumn	n.s.	n.s.	n.s.
Spring *vs.* summer	n.s.	Summer > spring (P=0.001)	n.s.
Spring *vs.* autumn	n.s.	n.s.	Autumn > spring (P=0.001)
Summer *vs.* autumn	n.s.	Summer > autumn (P=0.001)	Summer > autumn (P=0.001)
Biomass			
Winter *vs.* spring	n.s.	n.s.	n.s.
Winter *vs.* summer	n.s.	n.s.	n.s.
Winter *vs.* autumn	n.s.	n.s.	Autumn > winter (P=0.001)
Spring *vs.* summer	n.s.	Summer > spring (P=0.001)	n.s.
Spring *vs.* autumn	n.s.	n.s.	n.s.
Summer *vs.* autumn	n.s.	Summer > autumn (P=0.001)	Summer > autumn (P=0.001)

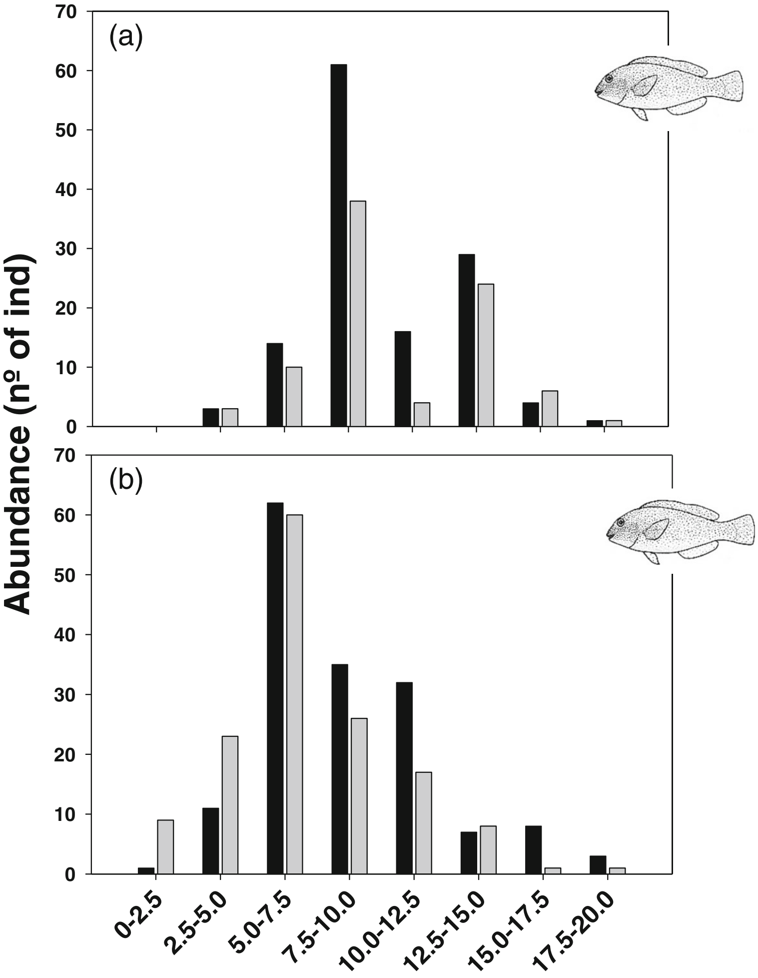

Fig. 6 Size structure (total length, cm) of the parrotfish, *Sparisoma cretense*, recorded by means of **a** UVCs and **b** SNs at seagrass adjacent to reefs (*black bars*) and seagrass interiors (*grey bars*)

abundance of *S. cretense* on hard bottoms of the study region is enhanced by frondose algal communities that provide food, as well as habitat, for associated epifauna, which are widely found in gut contents of *S. cretense* (Llinás et al. 1990; González 1991).

Patterns of juvenile abundance and biomass with varying proximity from reefs

Despite a lack of statistical significance, the abundance of juvenile *S. cretense* detected by means of UVCs was larger (2.35 times) in seagrass near than far away from reefs. Importantly, the biomass of juvenile *S. cretense* was consistently larger (1.90 times) in seagrass adjacent to reefs than in seagrass interiors through times and meadows. The abundance of juvenile *S. cretense* registered through SNs did not differ between seagrass adjacent and away from reefs. However, the biomass of juvenile *S. cretense* was larger (1.86 times) in seagrass adjacent to reefs than in seagrass interiors, consistently through times and meadows. Juveniles inhabiting seagrass adjacent to reefs were, in fact, larger than those in seagrass interiors. This observation complements results from UVCs, and seems to point out towards a transition of juveniles from seagrass interiors to seagrass near reefs as juveniles increase in size, so juveniles are located in the vicinity of their habitat as adults (reefs).

In the study region, *S. cretense* juveniles display a high degree of association with *C. nodosa* seagrass, remaining within the canopy to avoid predation; in turn, movements away this canopy are uncommon (F. Espino pers. obs.). Similarly, *S. cretense* juveniles are tightly associated with vegetation in the Mediterranean; *S. cretense* juveniles are, indeed, considered as migrant juveniles in seagrass meadows during their early life stages (Kalogirou et al. 2010). In the Canary Islands, most *C. nodosa* meadows near reefs are separated by narrow sandy corridors, usually about 10–20 m wide, similar to unvegetated 'haloes' around coral reefs (Randall 1965; Ogden 1976; Ogden and Zieman 1977). Most likely, this limits the movement of juveniles from seagrass to reefs and vice versa, and helps out to explain the 'concentration' of large-sized juveniles in seagrass in the vicinity of reefs. The capacity of juveniles from a range of parrotfish species to move through seagrass canopies has been previously acknowledge (Ogden and Zieman 1977; Hyndes et al. 2003). Individuals around 15–20 cm TL likely have a sufficient movement capacity to move towards reefs. This would imply that juvenile parrotfish remain, in average, ~1.43 years in *C. nodosa* seagrass meadows before moving to reefs, according to Lozano and González (1993).

Patterns of juvenile abundance and biomass through times

Sparisoma cretense is a gonochorist species that, in the study region, mainly spawns from the end of June to the end of October (González 1991, 1993), so the presence of juveniles is particularly large in late summer and autumn. The spawning period, however, can extend from May to December, depending on environmental conditions. In this context, the release of gametes can be fractionated through several spawning events, so *S. cretense* is considered as a heterochronic species (Pérez 1979; González 1991, 1993). This wide reproductive period of *S. cretense* explains the presence of juveniles throughout an entire annual cycle on *C. nodosa* seagrass meadows, including juveniles ranging from 1 to 19.2 cm TL. This pattern contrast with the recruitment periodicity of some fish species of the Sparidae family (e.g. *Spondyliosoma cantharus*, *Pagellus erythrinus*), which recruit on *C. nodosa* seagrass meadows in shorter periods and, subsequently, show clear cohorts of individuals within the same size range (Espino et al. 2011a, b). A similar outcome was observed in the Mediterranean (Petrakis and Papaconstantinou 1990), where *S. cretense* recruits were detected all year round, including several cohorts.

UVCs *vs.* SNs: methodological considerations

Despite both sampling techniques showed a similar pattern for the abundance and biomass of juveniles, two clear differences were detected. First, adults were exclusively registered by UVCs, as adults can easily escape from bottom trawls due to their large swimming capacity. Second, the size distribution of juveniles was different, as small-sized individuals (TL<10 cm) were underestimated by UVCs. Small fish hide within seagrass canopies and are difficult to spot through UVCs, while an accurate size measure is, at the same time, harder to obtain relative to SNs. The accurate distribution size recorded by SNs reinforces results obtained for the biomass of juveniles; juvenile in seagrass near reefs exhibited a larger mean total length than those at seagrass interiors.

Acknowledgments Financial support was received from the Government of the Canary Islands and the EU ERDF within the framework of the PCT MAC 2007–2013 programme, project GESMAR, in close liaison with the insular administration of *Cabildo de Gran Canaria*. F. Tuya was supported by the MINECO Ramón y Cajal programme. We would like to thank L. Ortega, A. Ulibarri, H. Hernández-Zerpa and T. Sánchez for assisting during collection of field data. This research was conducted under the current environmental and fishery regulations of the Canary Islands.

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