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Ecological characterization of dredged and non-dredged bivalve fishing areas off south Portugal

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Macro and meiobenthic communities of two fishing areas (Vilamoura and Lagos) in the western part of south Portugal (Algarve coast) were analysed. Both locations had been under severe dredge-fishing impact until four years previously. Vilamoura has since continued to be dredged, while fishing activity in Lagos was stopped in 1995 as a response to overfishing. For each location, three replicate areas were analysed at depths of 7–9 m. In each of these areas, 18 quadrats for macrofauna and 12 cores for meiofauna were randomly sampled by SCUBA divers during September 1999. The Shannon–Weiner diversity index was higher for meiofauna in the fished area, whereas macrofauna diversity was higher in the recently non-fished area. Bray–Curtis dissimilarity between the two areas was 87.82%. Major differences were found between Ampeliscidea, *Amphiura mediterranea*, *Spisula solida*, Haustoriidae, Nemertinea and *Diogenes pugilator* populations at the two sites. There was higher abundance but lower biomass of potential macrofaunal scavengers in the fished area, and carnivore biomass was also higher in this area. Deposit-feeders dominated meiofauna abundance in both study areas. The community structure of the continuously fished area was dominated by small, opportunistic, short-lived species while the community structure of the recently non-fished area was dominated by more fragile and long-living sessile organisms.

INTRODUCTION

Commercial fishing has one of the greatest impacts on the marine benthic ecosystem, as benthic habitats are disturbed when fishing gear is dragged across the sea-floor. The environmental effects of shellfish dredging have received special attention throughout the world during recent decades (e.g. Caddy, 1973; Conner & Simpson, 1979; Eleftheriou & Robertson, 1992; Hall et al., 1993; McLoughlin et al., 1991; Dare et al., 1993; Jennings & Kaiser, 1998; Gilkinson et al., 1999; Hall-Spencer & Moore, 2000). In Portugal, a dredge fishery has exploited clam populations since 1969, and currently has great socio-economic importance. Target species are *Spisula solida*, *Donax trunculus*, *Venus striatula*, *Pharus legumen* and *Ensis siliqua*. In the Algarve (south Portugal), 57 bivalve fishing boats with a maximum 100.8 HP are licensed. The dredges used are heavy iron structures with a net bag and a toothed lower bar at the mouth. The teeth are 10–50 cm long, depending upon the target species, and act as a rake when the dredge is dragged over the sea bottom (Gaspar, 1996).

Despite most studies having shown that it is possible to detect short-term changes in community structure in response to fishing disturbance (e.g. de Groot, 1984; Currie & Parry, 1999; Kaiser & Spencer, 1996), long-term changes (see Frid et al., 1999) are more difficult to evaluate and are consequently scarce in the published literature. When an area has been continuously fished for several decades, it can be difficult to distinguish between changes in the community caused by fisheries disturbance and those caused by natural phenomena (Currie & Parry, 1996). Kaiser et al. (1998) have referred to the importance of evaluating the ecological relevance of fishing disturbance vs natural perturbations, which will vary between different habitats. To analyse these long-term effects, comparisons are usually conducted between areas that are fished and non-fished, but interpretation can be difficult as non-fished areas usually differ physically from commercial fishing grounds. A variant on this approach is to examine fishing effects in an area that has been closed to fishing (Tuck et al., 1998; Bradshaw et al., 1999).

Traditionally, bivalve fishing grounds have been over-exploited, and it is necessary to take measures to mitigate reductions in target species abundance. In the Algarve region these measures include TACs, minimum mesh size (25 mm) and closure periods (from 1 May until 15 June). This closure aims to protect spawning individuals. In heavily exploited areas, larger periods of closure could be needed. However, the complete closure of an entire fishing area can have high socio-economic impact. As an alternative, temporary closure of fishing sub-areas to allow their recovery can be a useful tool for fishery management.

In this study, we analysed a recently four-years non-fished area (Lagos) with a continuously fished area (Vilamoura), and differences in benthic macrofaunal and meiofaunal diversity, abundance, and biomass are discussed, as well as in the relative importance of feeding groups.

MATERIALS AND METHODS

Study site

The Algarve coast (south Portugal) extends from Cabo São Vicente (08°59′W) in the west to the border with Spain in the east (07°24′W) (Figure 1). The continental shelf off the Algarve is narrow. Both study sites—the

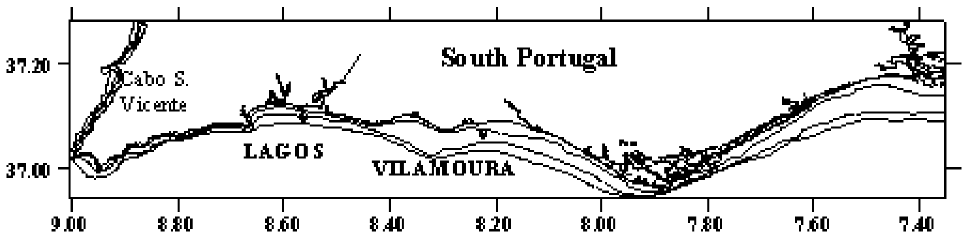

Figure 1. The south Portugal (Algarve) coast, showing location of the studied areas: Vilamoura (continuously fished area) and Lagos site (recently non-fished area).

continuously fished area, Vilamoura (37°05′N 08°02′W), and the recently non-fished area, Lagos (37°08′N 08°06′W)—are located in the western part of the Algarve coast. Drift currents (~0.25–0.50 m s^{-1}; Fiúza, 1983) run westwards parallel to the shore at 30 m depth and predominate over tidal currents. The two locations have similar hydrologic (water temperature, salinity, pH, etc.), depth (7 to 9 m) and sea bottom characteristics (sandy sediment in both areas) (Moita, 1986; Dias, 1987; Teixeira, 2000; Vieira et al., 2000). Due to the low depth of the sampling sites, changes in sediment characteristics (granulometry, organic content, etc.) may occur as a consequence of weather conditions.

Experimental design and sampling

Samples were collected at 7–9 m water depth during September 1999. At both study sites, three areas (~50×50 m) were analysed. At each of these replicated areas 18 quadrats (0.0625 m^2×0.15 m) for macrofauna, and 12 corers (0.001 m^2×0.15 m) for meiofauna were randomly placed and sampled by SCUBA divers. The sediment in the area of the quadrats was carefully dug with a spade to 1-mm mesh bags. Corers samples were sealed *in situ*, after collection. The number of replicates to be used was determined after considering a previous study in the same areas performed by Chicharo et al. (2000), and following Elliot (1977):

$$N = s^2 \times (m \times D)^{-2} \quad (1)$$

where: N is the number of replicates, s is the sample variance, m is the mean density per sample unit, and D is the sample precision (accuracy = SE/m). Because spatial aggregation of benthic organisms changes over time and space, variance is highly sensitive to mean density (Downing, 1989). To reduce this variability, sampling variance was calculated from the empirical algorithm for marine benthos by Vezina (1988):

$$s^2 = 1.641 \times m^{1.219} \quad (2)$$

where m is the mean density per sample. Macrofauna samples were sieved immediately after collection, on the surface, through 1-mm mesh bags.

Laboratory procedures

Meiofauna samples were sieved through a 150-μm mesh. Both macrofauna and meiofauna samples were preserved in 70% ethanol. Organisms were sorted to the lowest possible taxonomic level and counted. Ash free dry weight was calculated for bivalve biomass determinations. These animals were dried at 60°C until constant weight was reached (at least 48 h) and then burned at 450°C for three hours in a muffle-furnace. Linear measurements of the less abundant species of bivalves, gastropods and echinoderms were recorded and used for macrofauna biomass calculations, following Gamito (1994) and Sprung (1993, 1994a). Meiofaunal biomass was calculated following Sprung (1994b), Banse (1982) and Knox (1986).

Data analysis

Species diversity was calculated using the Shannon–Wiener index, H′ (Daget, 1979). Significant differences in meiofaunal and macrofaunal diversity and trophic groups between areas were analysed using one-way analysis of variance (ANOVA) (*F*-test) ($P<0.05$), performed with the Statistic V.5 software package. The specific contribution of macrofauna species to the observed differences in Bray–Curtis dissimilarity between sites was analysed using the SIMPER routine ('Similarity percentages') of the PRIMER (Plymouth Routines in Multivariate Ecological Research) software package (Clark & Warwick, 1994). The selected value for the percentage cut-off was 100.0. Analyses were carried out using square-root transformation to normalize the data.

Categorization of macrofauna (Table 1) and meiofauna (Table 2) into trophic groups was based on Feder (1981), Commito & Shrader (1985), Rield (1986), Bemvenuti (1994), Gamito (1994), McKillup & McKillup (1994), Sprung (1993, 1994a), Fish & Fish (1996) and Skoeld & Rosenberg (1996). We considered carnivores and omnivores to be potential scavengers, as proposed by Lindeboom & de Groot (1998). Many species can exhibit different modes of feeding in particular situations, depending, for instance, on their nutritional condition. Taxa were assigned to one trophic group according to the most usual (more frequent) feeding habit they exhibit (based on literature references). Thus, macrofauna taxa that may act as both suspension-feeders and deposit-feeders were considered to be preferentially suspension-feeders and not deposit-feeders. Also, as it is difficult to differentiate meiofaunal scavengers from deposit-feeders, we only consider a deposit-feeding group and a carnivorous group. Herbivores include grazers, some of which can be detritivores.

Table 1. *Trophic categorization of macrofauna taxa at the continuously fished (Vilamoura) and the recently non-fished (Lagos) study areas. For calculations purposes taxa were assigned to the most common feeding habit (the first listed, when several indicated).*

	TAXA		Occurrence	
	MACROFAUNA	Feeding habits	Lagos	Vilamoura
	Nemertina			
Nemertinea n.id.		SC, C	×	
	Sipuncula			
Sipuncula n.id.		DF	×	
	Annelida			
	Polychaeta			
Aphroditidae		SF, DF	×	
Capitellidae		DF	×	
Cirratulidae		DF	×	
Eunicidae		DF	×	×
Phyllodocidae		C	×	
Glyceridae		SF	×	
Hesionidae		C	×	
Magelonidae		C	×	
Maldanidae		SF, DF	×	
Nephtydidae		SC, C	×	×
Nereidae		C, SC, DF	×	×
Opheliidae		DF	×	
Orbiniidae		DF	×	×
Oweniidae		SF	×	×
Sabellaridae		SF	×	
Sabellidae		SF	×	
Spionidae		SF, DF	×	
Terebellidae		DF	×	
	Mollusca			
	Polyplacophora			
Poliplacophora n.id.		HV		×
	Bivalvia			
Abra alba				
Abra ovata		DF	×	
Acanthocardia aculeata				
Acanthocardia spinosa				
Acanthocardia tuberculata		SF, DF	×	×
Acanthocardia sp.				
Anomia ephippium		SF, DF		×
Chamelea gallina		SF	×	×
Callista chione		SF, DF	×	
Clausinella brongniartii		SF, DF		×
Corbula gibba		SF	×	
Donax semistriatus		SF	×	
Donax trunculus		SF	×	
Donax variegatus		SF	×	
Donax vittatus		SF		×
Dosinea exoleta		SF, DF		×
Ensis ensis		SF	×	
Ensis siliqua		SF	×	
Pharus legumen		DF	×	
Loripes lucinalis		SF, DF		×
Lutraria anguistor		SF	×	
Lyonsia norwergica		SF		×
Mactra corallina		SF	×	×
Mactra glauca		SF		×
Mesalia brevialis		SF, DF	×	
Modiolus modiolus		SF		×
Musculus costulatus		SF		×

(*continued*)

Table 1. (*Continued*).

	TAXA MACROFAUNA	Feeding habits	Occurrence Lagos	Occurrence Vilamoura
Ostrea edulis		SF, DF		×
Pandora sp.		SF, DF	×	
Pecten sp.		SF, DF	×	
Petricola lithophaga		SF, DF		×
Pharus legumen		DF	×	
Scrobicularia plana		SF, DF	×	
Spisula elliptica		SF		×
Spisula solida		SF		×
Tellina tenuis		SF, D		×
Tellina incarnata		SF, D		×
Thracia pubescens		SF, DF		×
	Gastropoda			
Bulla striata		HV, DF	×	
Calyptraea chinensis		SC, C, DF		×
Cymbium olla		DF		×
Gibberula miliaria		HV, DF	×	×
Natica prietoi		SC, C	×	
Turritella communis		SF	×	
	Crustacea			
	Cirripedia			
Balanus perforatus		SF		×
	Ostracoda			
Ostracoda n.id.		HV, DF	×	
	Cumacea			
Pseudocuma longicornis		DF	×	
	Tanaidacea			
Apseudes latreillei		DF	×	
	Isopoda			
Eurydice pulchra		C		×
Isopoda n.id.		HV, DF	×	×
	Amphipoda			
Ampeliscidae		HV, DF		×
Podoceridae		HV, DF	×	×
Haustoriidae		HV, DF	×	×
	Decapoda			
	Natantia			
Processa parva		SC, C	×	×
Crangon crangon		SC, C	×	×
	Raptantia			
Crangon crangon		SC, C	×	×
Diogenes pugilator		SC, C		×
Liocarcinus pusillus		SC, C		×
Parthenope massena		SC, C		×
Pirimela denticulata		SC, C		×
Thia scutellata		SC, C		×
	Echinodermata			
	Asteroidea			
Astropecten irregularis		C		×
	Ophiuroidea			
Amphiura mediterranea		SF	×	×
Ophiopsila annulosa		SC, C		×
Ophiura texturata		SC	×	×
	Echinoidea			
Echinocardium cordatum		DF	×	×
Psamechinus miliaris		SC		×
	Hemichordata			
Branchiostoma lanceolatum		SF	×	x

DF, deposit-feeder; SF, suspension-feeder; C, carnivore; HV, herbivore; SC, scavenger.

Table 2. *Trophic categorization of meiofauna taxa at the continuously fished (Vilamoura) and the recently non-fished (Lagos) areas. For calculations purposes taxa were assigned to the most common feeding habit (the first listed, when several indicated).*

	TAXA		Occurrence	
	MEIOFAUNA	Feeding habits	Lagos	Vilamoura
	Plathelminthes			
Turbellaria n.id.		C	×	
	Tartigrada			
Tartigrada n.id.		?	×	
	Nematoda			
Nematoda n.id.		DF	×	×
	Nemertina			
Nemertinea n.id.		C	×	×
	Annelida			
Polychaeta n.id.		C, SF, DF	×	×
	Mollusca			
Bivalvia n.id.		SF, DF	×	×
Gastropoda n.id.		HV, DF, C	×	
	Crustacea			
Ostracoda n.id.		HV, DF	×	×
Copepoda n. id.		HV	×	×
Isopoda n. id.		HV, DF	×	×
Amphipoda n.id.		HV, DF	×	
Cumacea n.id.		DF	×	

DF, deposit-feeder; SF, suspension-feeder; C, carnivore; HV, herbivore; SC, scavenger.

RESULTS

Benthic communities

The number of macrofaunal taxa found at the two study sites was 44 and 59 at Vilamoura and Lagos, respectively. Owing to difficulties in specific identification of meiofauna taxa, only nine different taxa were identified in the fished area and 15 in the recently non-fished area. The mean abundance of macrofauna was higher in the recently non-fished area, 12.198 ±4.439 ind m^{-2}, than in the fished area, 4.006 ±1.328 ind m^{-2}. Similarly, mean meiofauna abundance was higher in Lagos, 49,216.67 ±43,975.9 ind m^{-2}, than in Vilamoura, 41,638 ±34,594.15 ind m^{-2}. However, mean biomass of macrofauna was higher in the fished area, 0.648 ±0.558 g m^{-2}, than in the non-fished area, 0.612 ±0.343 g m^{-2}. In contrast, mean biomass of meiofauna was higher in Lagos, 4.906 ±4.663 g m^{-2}, than in Vilamoura, 0.128 ±0.008 g m^{-2}.

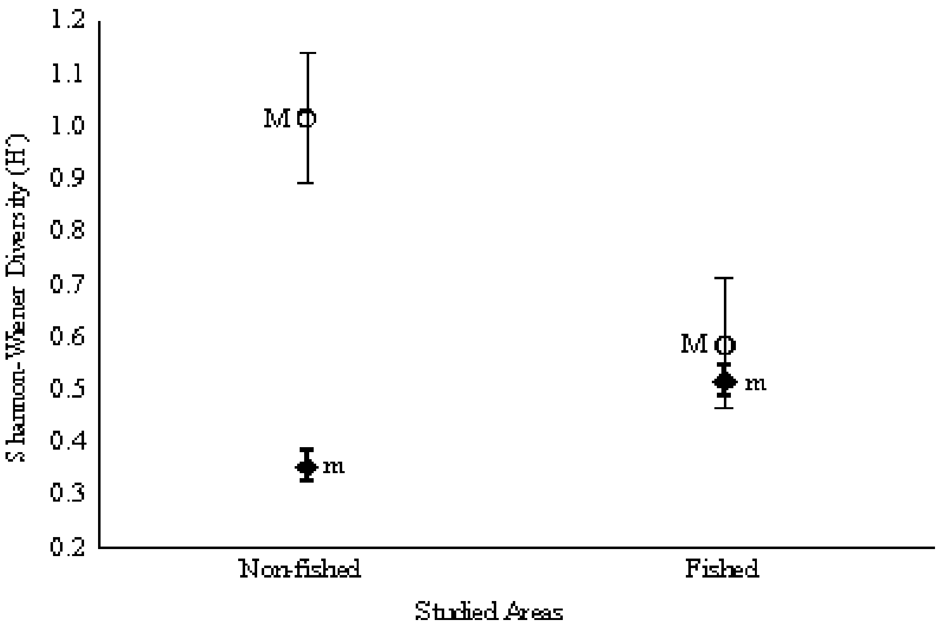

Figure 2. Macrofauna (M) and meiofauna (m) Shannon–Wiener (H′) diversity calculated for the continuously fished (Vilamoura) and the recently non-fished (Lagos) site. Error bars are standard error. Both macrofauna and meiofauna diversity between sites were significantly different ($P<0.05$).

Meiofaunal diversity was higher in the fished area (H′=0.516 ±0.093) than in the non-fished area (H′=0.352 ±0.091), whereas macrofaunal diversity was higher in the non-fished area (H′=1.014 ±0.136) in comparison with the fished area (H′=0.583 ±0.137) (Figure 2). One-way ANOVA results revealed significant differences in meiofaunal ($F(1,22)=18.97$; $P<0.0003$) and macrofaunal ($F(1,34)=90.028$; $P<0.0001$) diversity between the two areas. However, no significant differences ($P<0.05$) were observed between abundance and biomass, for macrofauna and meiofauna, in both areas.

The Bray–Curtis dissimilarity value for the comparison between the fished and recently non-fished areas was 87.82%, as resulted from the SIMPER analysis. The taxa that most contributed to this value were Ampeliscidea, *Amphiura mediterranea*, Haustoriidae, Nemertinea and *Diogenes pugilator* (more abundant in the non-fished area) and *Spisula solida* (more abundant in the fished area). The recently non-fished area was dominated by Ampeliscidea and *Amphiura mediterranea*, but Haustoriidae, Nemertinea and *Diogenes pugilator* were also abundant. *Spisula solida* and Nephtydidae were the most abundant taxa in the continuously fished area (Table 3).

Feeding habits

In the continuously fished area, total macrofauna suspension-feeders were the most abundant trophic group (63 ind m^{-2}), followed by scavengers (51.04 ind m^{-2}) and herbivores (37.31 ind m^{-2}), and deposit-feeders were the least abundant trophic group (24.64 ind m^{-2}) (Figure 3). Similarly, deposit-feeders were the least abundant trophic group in the non-fished area (97.92 ind m^{-2}), whereas herbivores were the most abundant (308.88 ind m^{-2}), followed by suspension-feeders (177.84 ind m^{-2}) and scavengers (135.36 ind m^{-2}). There were significant differences between the abundance of herbivores at the two study sites ($F(1,20)=5.623$; $P=0.028$).

When considering total macrofaunal biomass, the suspension-feeders trophic group was the most important, both at the fished area (27.680 g m^{-2}) and the recently non-fished area (29.968 g m^{-2}) (Figure 4). In the fished area, Vilamoura, the biomass of the other feeding groups were 0.428 g m^{-2} for deposit-feeders, 0.384 g m^{-2} for scavengers, and 0.028 g m^{-2} for herbivores. At Lagos, scavengers represented 3.493 g m^{-2}, and deposit-feeders and herbivores contributed with 2.466 g m^{-2} and 0.201 g m^{-2} of the total biomass, respectively.

The most abundant meiofaunal trophic group was the deposit-feeders, followed in order by the suspension-feeders, carnivores and herbivores. Deposit-feeders total abundance at Lagos and Vilamoura was 696,169.75 ind m^{-2} and 315,914 ind m^{-2}, respectively (percentages for each group in Figure 5). However, when considering the biomass of meiofaunal trophic groups, clear differences between Lagos and Vilamoura were

Table 3. *Average abundance of macrofauna at the continuously fished (Vilamoura) and the recently non-fished (Lagos) study sites as determined through SIMPER Bray–Curtis dissimilarity calculation.*

TAXA	Fished (Vilamoura)	Unfished (Lagos)	Cumulative percentage
	Average abundance		
Ampeliscidea	0.00	11.79	10.63
Amphiura mediterranea	0.67	8.93	18.99
Spisula solida	5.74	0.00	25.07
Haustoriidae	3.52	5.82	29.99
Nemertinea	0.00	5.35	34.88
Diogenes pugilator	0.00	5.01	39.69
Capitellidae	0.00	4.95	44.26
Podoceridae	1.61	4.72	48.30
Eunicidae	0.00	3.52	51.81
Nephtydidae	3.64	3.20	55.24
Sipunculo 2	0.00	3.38	58.22
Nereidae	3.22	1.52	61.19
Lysianassidae	0.67	3.25	64.14
Apseudes latreillei	0.00	3.36	67.00
Cirratulidae	2.65	1.07	69.87
Venerupis rhomboides	0.00	3.22	72.43
Processa parva	0.67	1.30	74.09
Amphictenidae	0.00	1.43	75.47
Ophiura texturata	0.94	0.54	76.79
Echinocardium cordatum	0.00	0.89	78.05
Eurydice pulchra	0.00	1.59	79.27
Divaricela divaricata	0.00	1.27	80.37
Gibberula miliaria	0.00	1.44	81.47
Maldanidae	0.00	1.07	82.52
Sipunculo 1	0.00	1.21	83.54
Branchiostoma lanceolatum	0.67	0.44	84.55
Chamelea gallina	0.00	0.89	85.46
Acanthocardia tuberculata	0.00	0.67	86.35

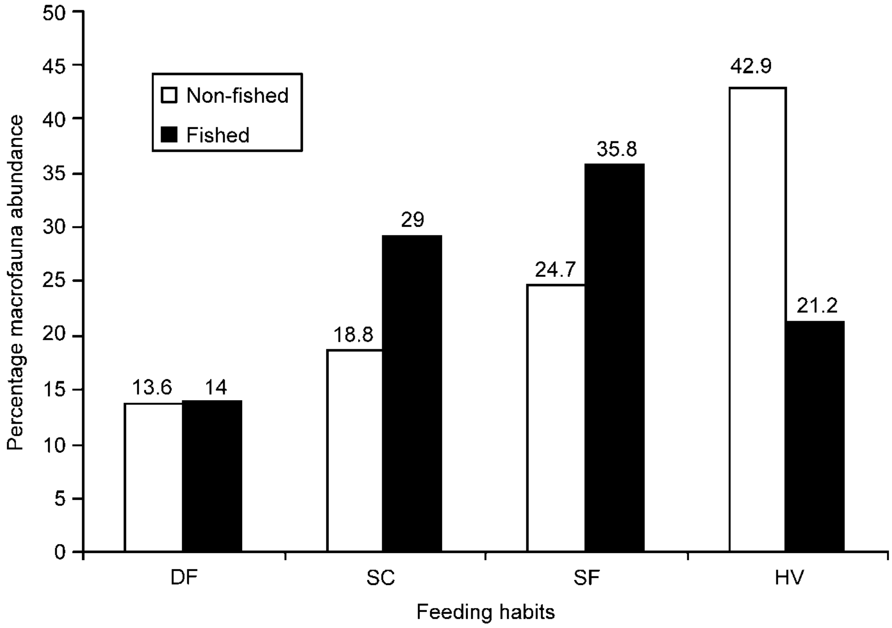

Figure 3. Percentage macrofaunal abundance at the continuously fished (Vilamoura) and the recently non-fished (Lagos) site by major trophic group. DF, deposit-feeder; SC, scavenger; SF, suspension-feeder; HV, herbivore. Error bars are standard error. For calculations purposes taxa were assigned to the most common feeding habit (the first listed, when several indicated, in Table 1). (*significant differences $P<0.05$).

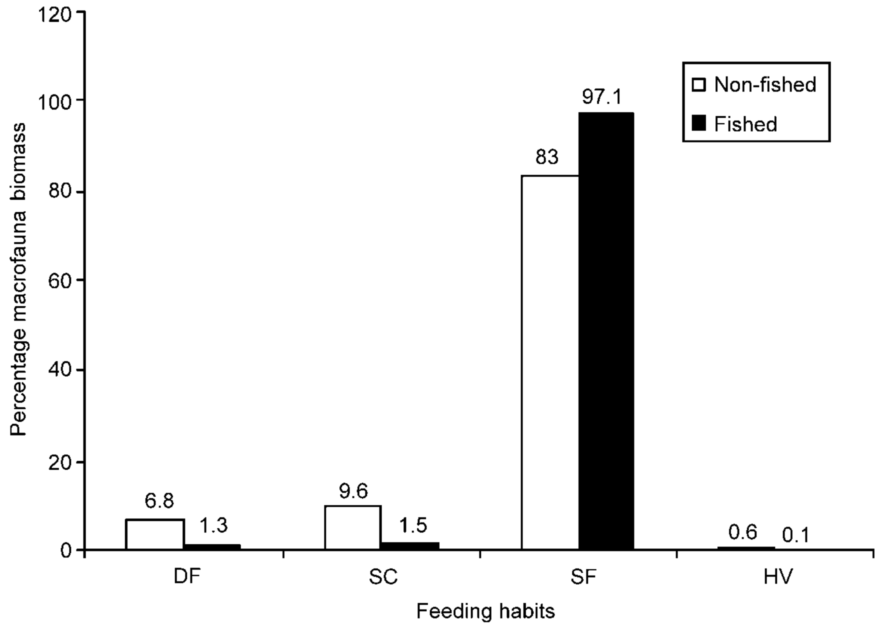

Figure 4. Percentage macrofaunal biomass at the continuously fished (Vilamoura) and the recently non-fished (Lagos) site by major trophic group. DF, deposit-feeder; SC, scavenger; SF, suspension-feeder; HV, herbivore. Error bars are standard error. For calculations purposes taxa were assigned to the most common feeding habit (the first listed, when several indicated, in Table 1).

observed (percentages for each group in Figure 6). Whereas in the recently non-fished area (Lagos) the total biomass of deposit-feeders was 50.122 g m^{-2}, at Vilamoura the most important trophic group was the carnivores (1.110 g m^{-2}), followed by the deposit-feeders (0.029 g m^{-2}), herbivores (0.014 g m^{-2}) and suspension-feeders (0.006 g m^{-2}). At Lagos, carnivores made up 12.88 g m^{-2} of the total biomass, suspension-feeders 10.009 g m^{-2} and herbivores 0.589 g m^{-2}. There were significant differences only between the biomass of deposit-feeders ($F=(1,27)=4.455$; $P=0.044$) and carnivores ($F=(1,22)=11.412$; $P=0.003$) at both study sites.

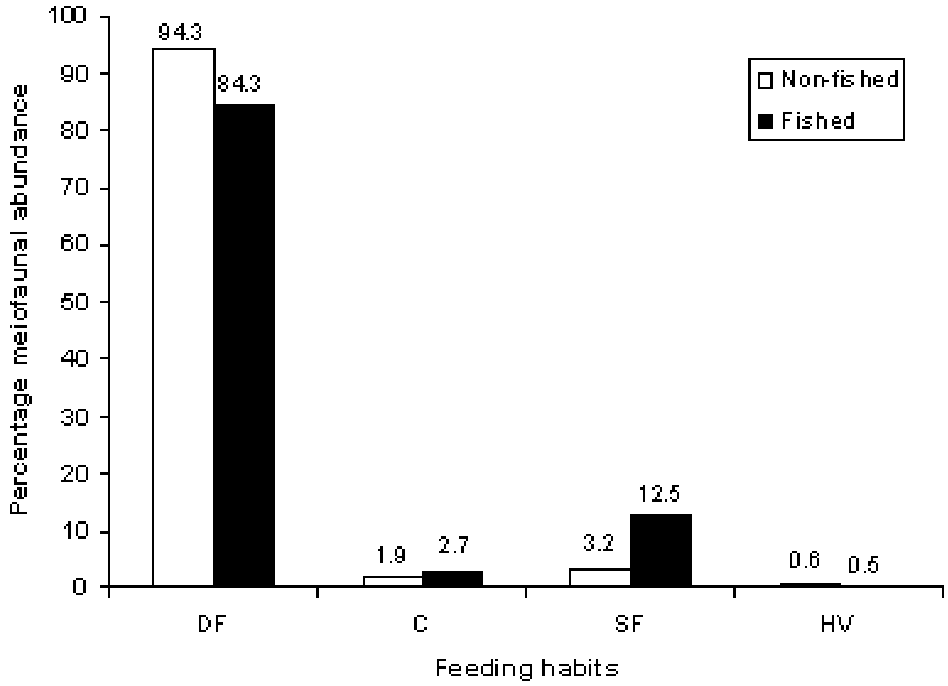

Figure 5. Percentage meiofaunal abundance at the continuously fished (Vilamoura) and the recently non-fished (Lagos) site by major trophic group. DF, deposit-feeder; C, carnivores; SF, suspension-feeder; HV, herbivore. Error bars are standard error. For calculations purposes taxa were assigned to the most common feeding habit (the first listed, when several indicated, in Table 1).

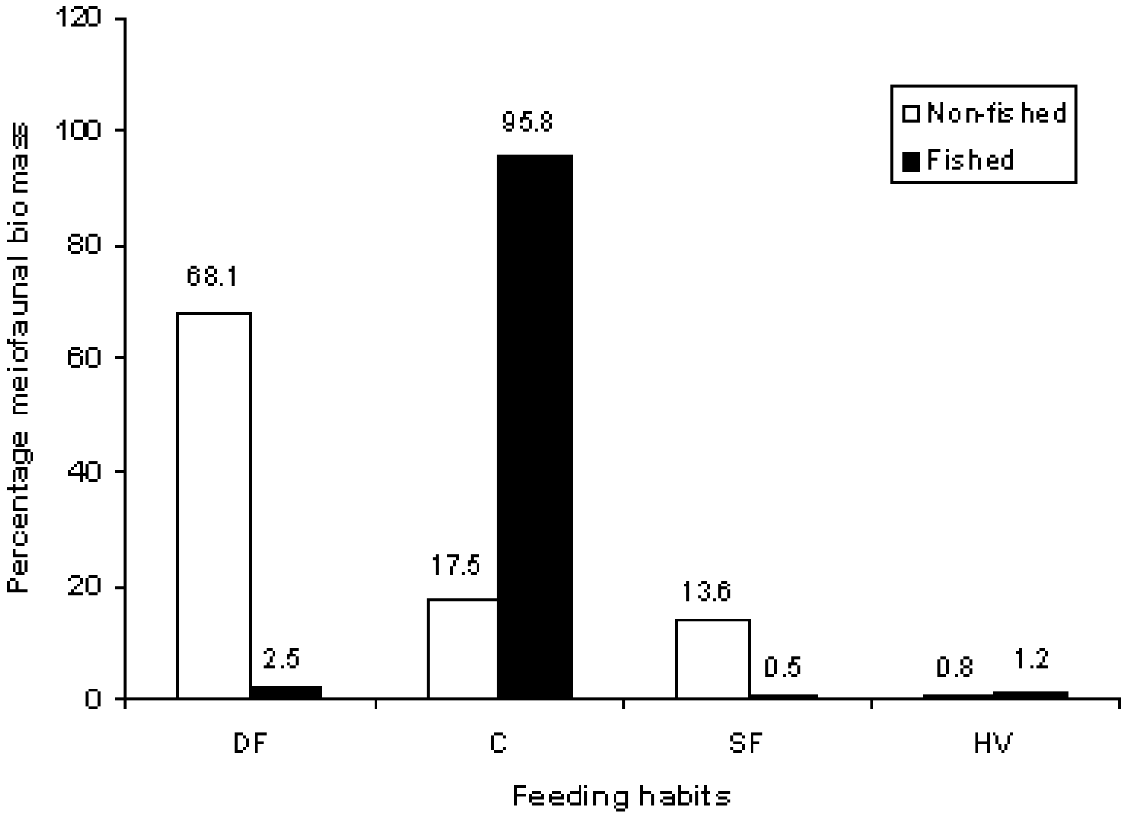

Figure 6. Percentage meiofaunal biomass at the continuously fished (Vilamoura) and the recently non-fished (Lagos) site by major trophic group. DF, deposit-feeder; C, carnivores; SF, suspension-feeder; HV, herbivore. Error bars are standard error. For calculations purposes taxa were assigned to the most common feeding habit (the first listed, when several indicated, in Table 1).

DISCUSSION

Changes of abundance, biomass, diversity and dominant trophic groups within macro- and meio-benthic communities were observed between the fished and recently non-fished locations. Macrofauna abundance and diversity were higher in the non-fished area (Lagos). This reduction of these community parameters in the fished area may be attributed to the continuous passage of the dredge teeth on the bottom, damaging and killing mostly macrofauna species that are unable to pass between the teeth. In fact, fragile species like polychaetes, namely Nephtydidae, Nereidae and Cirratulidae, were still very abundant in the fished area. Larger animals, such as the bivalve *Acanthocardium tuberculata* (more than 60 mm) or fragile species like the Nemertinea, Sipunculidae or the sea urchin *Echinocardium cordatum*, live only at the non-fished area. Thus, the continuous fishing impact in the Vilamoura area probably resulted in a dominance of *r*-selection opportunistic short-lived species such as polychaetes, and a decrease of long-lived sessile species such as sea urchin. Similar observations were described by Commito (1982), Bemvenuti (1994), Rumohr et al. (1998), Mortimer et al. (1999), Christensen et al. (2000) and Jennings et al. (2001).

Biomass of macrofauna species was higher in the fished area, as a result of the abundance of *Spisula solida* at the area.

Meiofauna in the fished and non-fished area was dominated by Nematoda, Copepoda and Polychaeta. Higher values of abundance and biomass were observed at the recently non-fished area (Lagos). Despite this, Shannon–Weiner diversity was lower in this area, owing to the dominance of Nematoda, which represented 90% of total meiofauna.

Demersal fishing activities provide food for scavengers in the form of damaged animals, which are left in the dredge track (Ramsay et al., 1988). The continuous fishing impact reduced the abundance of herbivores and increased the abundance of suspension-feeders and scavengers, as evidenced by Bray–Curtis dissimilarity results. The larger number of herbivores in the recently non-fished area, mainly amphipods, may be related to the presence of macroalgae that are unable to grow on the impacted area. Abundance of suspension-feeding and scavengers taxa, in the fished site, can be related to the input of organic dead material and to the increase of turbidity caused by the dredge.

Meiofauna are believed to be highly selective feeders with distinct and often highly specialized food niches (Kennedy, 1994). Analysis of meiofauna as a potential indicator of anthropogenic perturbation in aquatic ecosystems has often been limited to monitoring surveys for pollution (Pranovi et al., 2000). However, the meiofauna analysis may also reveal the existence of dredging disturbance, as it seems to occur in this study. In fact, the level of dredging disturbance was the factor that dramatically changed, when the two areas are compared. Both temporal (seasonal) and spatial natural fluctuations of abundance and biomass in both areas, even despite differences that may exist between them, are not expected to justify the magnitude of the changes observed. It may therefore be assumed that the observed differences in this study, in terms of biodiversity, relative abundance and biomass of feeding groups, and in the relation between opportunistic short-lived and long-lived sessile species, can be attributed to the different levels of the fishing impact. Since there are no previous data on the characteristics of the two areas before fishing activity began 40 years ago, we are not able to positively state that the non-fished area has reached its climax. However, observed changes indicate a trend and we would recommend monitoring the Lagos area for a period of two more years before allowing fishing activities. Therefore, based on our results, we anticipate a period of six years for the recovery of the previously fished area. Closing areas for such a long period of time could be a management solution, but difficult to implement due to social and economic pressure by fishermen. An integrated approach, considering the contribution of restocking methods could be useful in allowing a faster recovery of the fishing in impacted communities.

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