

Feeding ecology of benthic filter-feeders at Potter Cove, an Antarctic coastal ecosystem

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Abstract A rich benthic filter-feeding community is present at Potter Cove, South Shetland, in spite of some usually unfavorable conditions affecting their feeding ecology, such as low phytoplankton production in summer and high sedimentation rates. However, organic material that could fuel the benthic system, such as macroalgal fragments, was detected in the water-bottom interface year-round. Mean assimilation efficiency of several sizes of macroalgal particles under different inorganic particulate percentages varied between 26–51% in a clam, and 26–72% in two ascidian species. Estimated particle flux (feces) produced by ascidians varied according to species and abundance. The C:N ratio of feces was relatively high. Plasticity and profit from the available food sources contribute to the success of the filter-feeding community in Potter Cove.

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Introduction

One of the most relevant features observed in Potter Cove (South Shetland, Antarctica) is the existence of two different areas, the outer cove with high benthic primary production (macroalgae) and the inner cove with high benthic secondary production. A rich benthic community dominated by filter feeders occupies this area, in spite of what appears to be daunting conditions for obtaining nutrients (Robbins 1983, 1985a, b; Petersen 2007). These conditions include high sedimentation, mainly during summer, and generally low pelagic primary production. Despite these seeming handicaps, the filter feeding community flourishes in this environment. Filter-feeding bivalves and ascidians are large and numerous, contributing a great deal to the biomass. High concentrations of suspended inorganic particles can reduce the amount of food assimilated by filter-feeding ascidians, limiting the intake of utilizable food by a process of dilution and/or reducing the efficiency of assimilation of such food (Robbins 1985a, b; Tito de Moraes and Fiala-Médioni 1985). In summer, creeks formed by melting ice transport large amounts of inorganic material from the surrounding land into the cove, resulting in high sedimentation rates of about 18–30 g m⁻² day⁻¹ in the inner cove (Ferreyra et al. 2003). In Potter Cove, the sediment load in the water column is frequently enhanced in summer by resuspension of the fine bottom material when the sea surface is ice-free and winds result in turbulent mixing that affects the bottom down to a depth of 30 m (Schloss et al. 1999). The suspended sediment then affects

the penetration of light into the water column, which together with the deep vertical mixing explains the low phytoplankton biomass within inner Potter Cove (Schloss and Ferreyra 2002).

Water-column analyses from Potter Cove suggested that some organic material in the deposited sediments is released from the water–bottom interface even during winter (Kowalke 1999). Although scarce, this material seems to be the food source for benthic organisms, especially long-lived species that undergo growth and reproduction during winter (Sahade et al. 2004). The origin and composition of this material is, nevertheless, not completely understood. Recent studies using fatty acid profiles of different compartments (water column, sediments and benthic suspension-feeding species) revealed traces of detritus as well as a small contribution of phytoplankton from the water column (Graeve et al. 2007). One of the most reasonable hypotheses is that part of this material, possibly macroalgal fragments that originated in the outer cove, is continuously carried into the inner cove by clockwise water currents (Ferreyra et al. 2003). This material is sometimes easy to observe as little brown-greenish particles floating on the sea surface and a thick bed of brown material that is patchily present on the bottom. Macroalgal fragments are available; however, it is not clear if they can be a food source for suspensivores. Observations on stomach contents of ascidians revealed the presence of recognizable macroalgal fragments, which reached up to 500 μm in size (Tatián et al. 2004). The use of macroalgal fragments as food depends on their capacity to retain and assimilate the carbon and nitrogen of these particles. The uptake of phytoplankton and particulate organic matter from the water column by benthic suspension-feeding animals is known to be one of the major trophic pathways in marine ecosystems. In phytoplankton-impooverished coastal waters, the role of benthic suspension feeders is important. Their fecal depositions nourish benthic fauna, being agents of sedimentation of both lithogenic and organic particles, enhancing particle flux near the bottom (Ahn 1993). Thus, the amount and composition of these deposits are relevant for the coupling between pelagic and benthic systems.

The focus of this study was to measure assimilation efficiencies of natural and artificial seston (powdered macroalgae and diatomaceous earth), by a series of experiments performed with one bivalve and two ascidian species. The aim was to reveal insights into the assimilation efficiencies of filter feeders, considering a food source other than phytoplankton under different inorganic particulate percentages. The deposition rate measured in ascidians feeding on natural seston, as well as the C:N composition of deposits (feces) should make it possible to estimate the contribution of ascidians to

the particle flux in the bottom boundary layer in Potter Cove.

Methods

Field site

Potter Cove, where the Argentinean Jubany Station and the Argentinean–German Dallmann laboratory are situated, is an inlet of the larger Maxwell Bay system, at King George (25 de mayo) Island, South Shetlands ($62^{\circ}14'S$, $58^{\circ}39'W$) (Fig. 1). The inner cove is characterized by soft bottoms consisting of fine sediments, whereas the glacier front contains moraine deposits. Ascidians are the dominant macrobenthic fauna from 20 m while pennatulids and the bivalve *Laternula elliptica* (King and Broderip 1831) are the most abundant macrobenthic fauna at shallower depths (Sahade et al. 1998). A dense macroalgal community attached on hard substrate dominates the mouth of the cove and the glacier front. The total area of the cove stretches to over 4.5 km^2 and has a maximum depth of 100 m.

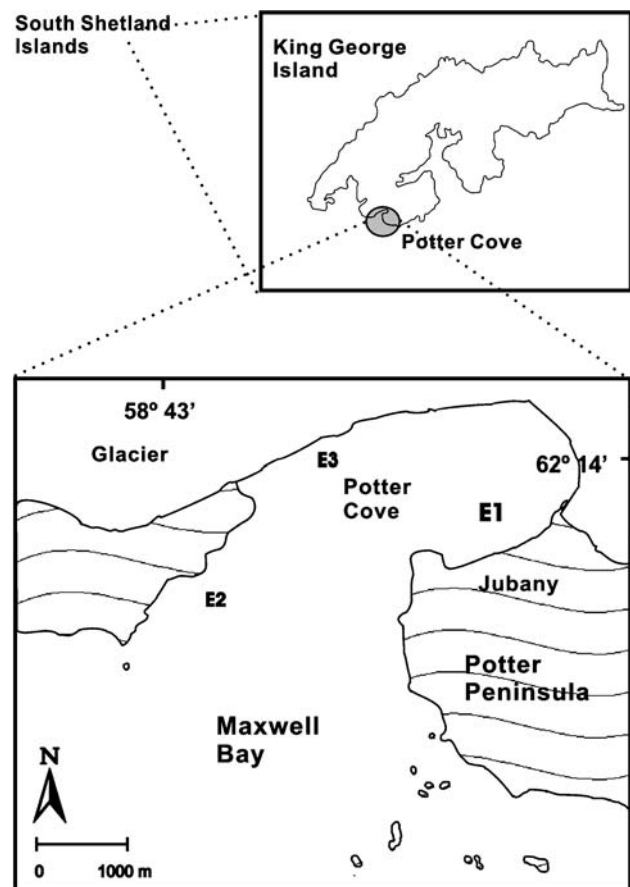


Fig. 1 Map of Potter Cove. E1: sampling site. E1, E2, E3: sites with available data on ascidian abundance are from Sahade (1999)

Experimental procedures

Assimilation efficiency

The test filter feeders used were: the bivalve *Laternula elliptica* and the ascidians *Cnemidocarpa verrucosa* (Lesson 1830) and *Pyura setosa* (Sluiter 1905). Experiments were carried out during February and March 2002 (with the bivalves) and during January–March 2004 (with the ascidians) in aquaria located in a temperature-regulated room. Seawater was first pumped from the cove (1–3 m depth) into tanks where the temperature was maintained at $0 \pm 1^\circ\text{C}$. Seawater was filtered to remove coarse suspended material before filling the experimental aquaria. To simulate the particulate macroalgal fragments observed on the sea surface (Fig. 2), provided diets comprised of powdered kelp fragments and inorganic material (precombusted diatomaceous earth) suspended in filtered seawater. The kelps *Desmarestia mensiezii* and *D. anceps* were collected in the intertidal region of the outer cove. They were washed in freshwater to remove the salts, and a portion of the material

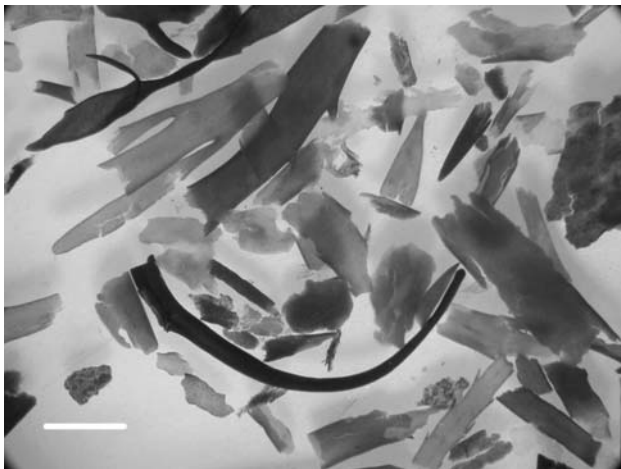


Fig. 2 Macroalgal fragments taken from the water surface at Potter Cove. Scale bar = 2 mm

was lyophilized for 48 h. The freeze-dried material was ground to powder and sieved through 50, 125 and 250 μm mesh. Diatomaceous earth was ashed (5 h, 450°C) to eliminate residuals of organic matter and sieved through the same sieves as the plant material. The experimental diets varied by different particle sizes and macroalgae/diatomaceous earth percentages (Table 1). To reflect the inorganic load differences near the bottom in a depth profile, the diets provided to *L. elliptica* had less inorganic percentage than those supplied to ascidians. At shallower depths (where the bivalves dominate), the bottom consists of 95% sand (Mercuri et al. 1998). This sediment is less susceptible to resuspension than the fine silt-clay fraction that characterizes the bottom at 30 m depth where ascidians occur at their highest abundance despite the high inorganic load present.

All diets were stored at -20°C and thawed before use. Animals were collected by SCUBA, immediately transported to the laboratory, cleaned of epibionts and debris under flowing seawater and kept for several days in aquaria for acclimatization (open system with running sea water, at $0 \pm 1^\circ\text{C}$). Seven specimens of each species were placed in individual 2 l-PVC aquaria, and received food through the oral siphon using a Pasteur pipette with a solution made of yeast and carmine-red in seawater. The time until the production of red feces (gut-residence time, GRT, Table 2) was recorded. Then, 5–7 specimens were placed in individual 1 l-PVC flasks to facilitate collection of feces, and two additional flasks containing pebbles instead of bivalves were used as controls. The flasks were placed randomly at the bottom of a 90 l aquarium, a closed system filled with $0.45 \mu\text{m}$ filtered seawater. Animals were starved in the experimental aquarium for 2 days. Water was changed at the beginning of each experiment. Animals were fed with the addition of different diets every 24 h for 3–5 days.

An additional experiment was performed feeding ascidians with natural seston (running sea water) in an open system (diet 5, Table 1). Water in the aquarium was stirred using airstones and resuspension pumps to keep particles in suspension. Nevertheless, possibility of circulation artifacts

Table 1 Diet composition used in the experiments performed to estimate assimilation efficiency (AE)

Species	Diet	Composition	Size particles (μm)
<i>L. elliptica</i>	1	Particulate macroalgae (60%), diatomaceous earth (40%)	<50
	2	Particulate macroalgae (30%), diatomaceous earth (70%)	<50
	3	Particulate macroalgae (60%), diatomaceous earth (40%)	<125
	4	Particulate macroalgae (60%), diatomaceous earth (40%)	<250
<i>C. verrucosa</i> and <i>P. setosa</i>	5	Running seawater, natural seston	
	6	Particulate macroalgae (25%), diatomaceous earth (75%)	<50
	7	Particulate macroalgae (13%), diatomaceous earth (87%)	<50
	8	Particulate macroalgae (25%), diatomaceous earth (75%)	<125

Table 2 Abbreviations used in the present study

Experiment	Definition	Abbreviation
Assimilation efficiency	Gut-residence time	GRT
	Total suspended particulate matter	SPM
	Dry mass	DM
	Organic matter	OM
	Assimilation Efficiency	AE
Biodeposition rate and estimation of particle flux	Chlorophyll a	Chl a
	Particulate organic carbon	POC
	Particulate organic nitrogen	PON
	Carbon/Nitrogen ratio	C:N
	Biodeposition rate	BR
	Mass-specific biodeposition rate	MSBR

caused by the containers on the experiments was considered; thus, water samples were taken by triplicate every 24 h, and then filtered through precombusted and pre-weighed GF/F filters. Deposits were also collected. To determine the total suspended particulate matter (SPM) in the case of water samples, and the total dry mass in the case of feces and discriminate between the organic (OM) and the inorganic matter, the dry and ash-free dry mass of the filters and feces were dried (60°C, 24 h), ashed (450°C, 5 h) and weighed. Assimilation efficiency (AE) was calculated using the ratio of Conover (Navarro and Thompson 1994): the organic matter calculated as the percentage of mass loss after combustion of water samples, was compared with the corresponding percentage of mass loss after combustion of feces. According to Ahn (1993), *L. elliptica* produces feces and pseudofeces. As it was not possible to continuously follow the deposition activity, a parallel experiment was used which consisted of collecting pseudofeces with a pipette for correction purposes.

Biodeposition rate and particle flux

In the experiment corresponding to diet 5 (running seawater, natural seston) determinations of chlorophyll a (Chl a) were also performed in water samples from aquaria. Pigments were extracted using acetone and determined by spectrophotometry (Strickland and Parsons 1972). Particulate organic carbon (POC) and particulate organic nitrogen (PON) were also determined from water samples and feces deposited using a Carlo-Erba NA-1500 analyzer, after removing calcium carbonate with ClH. The quality of the natural seston and feces produced was considered by means of the carbon/nitrogen (C:N) ratio. Once experiments were terminated, ascidians were dissected. Inorganic structures characteristic of the tunic, such as the bristles which cover the tunic of *P. setosa*, can introduce errors such as epibionts (encrusting bryozoans, microalgae) and inorganic material that may have adhered. Thus, the tunic was removed before

mass determinations (60°C, 24 h). The biodeposition rate (BR) is calculated as milligram dry mass of feces produced per individual per day ($\text{mg specimen}^{-1} \text{day}^{-1}$). Mass specific biodeposition rate (MSBR) was calculated as mg dry mass of feces produced per gram dry mass of animals per day ($\text{mg gDM}^{-1} \text{d}^{-1}$). Total particle flux, and fluxes of particulate organic carbon (POC) and particulate organic nitrogen (PON) by deposits produced by *C. verrucosa* and *P. setosa* were estimated, relating MSBR (and its percentage of POC and PON) with data on mean biomass and abundance ($\text{individuals m}^{-2}$) of both ascidians at different sites of Potter Cove at a depth of 30 m. These sites are E1: southern inner cove, muddy bottoms; E2: outer cove, hard substrates; E3: northern inner cove, moraine deposits, Fig. 1 (Sahade 1999).

Statistical analyses

The differences between the AE between diets were assessed in the three species by one-way analysis of variance (ANOVA) at a significance level of 5%. Homogeneity of variances was tested using Cochran's *C* test. Linear regression analyses were performed pooling data of both ascidian species, to relate BR to body dry mass and water quality by means of SPM, Chl a and C:N ratio in water samples from diet 5 (natural seston).

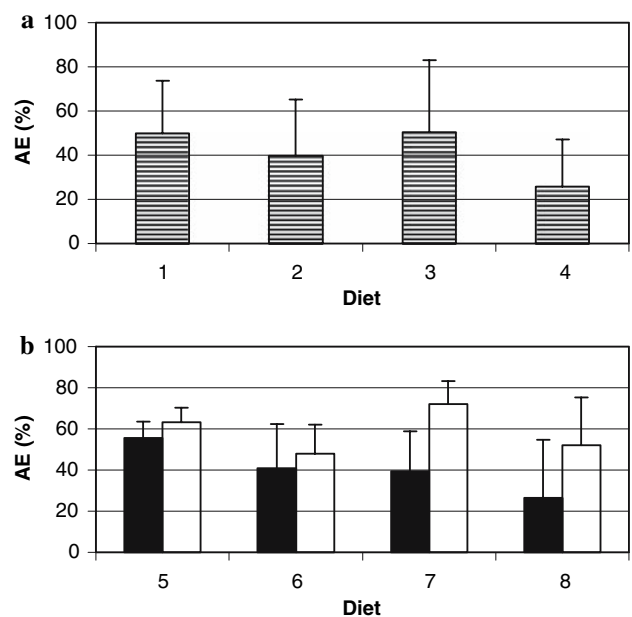
Results

All *L. elliptica* specimens produced red feces 15–19 h after they were fed with the yeast–carmine solution. On the other hand gut-residence time (GRT) for the ascidians was difficult to estimate, because specimens commonly rejected the carmine solution. The different parameters measured in the water samples during the experiments are summarized in Table 3. Mean values of total suspended particulate matter (SPM), corresponding to macroalgal diets, varied between

Table 3 Total suspended particulate matter (SPM, mg l⁻¹), organic matter (OM, %), chlorophyll a (Chl a, µg l⁻¹), and C:N ratio measured in water samples during the experiments (mean ± SD)

Diet	<i>L. elliptica</i>		<i>C. verrucosa</i>				<i>P. setosa</i>			
	SPM	OM	SPM	OM	Chl a	C:N	SPM	OM	Chl a	C:N
1	2.8 ± 1	53 ± 14								
2	2.9 ± 1.2	31 ± 8								
3	3.1 ± 0.4	55 ± 23								
4	4.3 ± 0.4	28 ± 20								
5			8.6 ± 6	26 ± 19	0.25 ± 0.17	8.6 ± 3.2	8.3 ± 4	21 ± 11	0.2 ± 0.15	7.4 ± 0.9
6			2.8 ± 1.2	35 ± 9			3.3 ± 0.8	30 ± 7		
7			2.4 ± 0.5	31 ± 9			4.3 ± 0.8	31 ± 12		
8			4.8 ± 2.4	35 ± 4			3.1 ± 1.3	34 ± 2		

2.4 and 4.8 mg l⁻¹, while those measured in current seawater (natural seston) were considerably higher (8.3–8.7 mg l⁻¹). Slightly higher values of Chl and C:N ratio were registered in water samples during experiments performed with *C. verrucosa* than those of *P. setosa* (diet 5). All diets were assimilated from the three test species; mean of the assimilation efficiency (AE) varied between 26–50% in the case of *L. elliptica* (Fig. 3a), 26–56% for *C. verrucosa* and 48–72% for *P. setosa*, reaching high AE when natural seston was supplied (Fig. 3b). Differences in AE between diets were not significant in *L. elliptica* (ANOVA $F = 1.38$, $n = 28$, $P = 0.27$), but a decrease in AE was observed when particles approached 250 µm in size (Fig. 3a). On the other hand, *C. verrucosa* was more influenced by seston composition. Although the differences were not significant (ANOVA $F = 2.01$, $n = 23$, $P = 0.14$), there was a decrease in the AE from natural seston to experimental seston, from lower inorganic percentage to higher inorganic percentage, and from smaller particle size to larger particle size (Fig. 3b). This was not the case with *P. setosa*, which neither lowered assimilation under higher particulate inorganic concentration (diet 7) nor with larger particle size (diet 8) (ANOVA $F = 2.65$, $n = 20$, $P = 0.08$). Comparison between both ascidian species showed that differences in AE were not significant when specimens were fed on natural seston (ANOVA $F = 2.81$, $n = 11$, $P = 0.12$), but they were significant when fed on experimental seston (ANOVA $F = 8.51$, $n = 32$, $P = 0.006$). Bio-deposition rate (BR) of pooled data of both ascidian species was not related to body dry mass, Chl a, SPM and C:N ratio under natural seston (diet 5), as is shown in Table 4. While it was not possible to observe production of pseudofeces during the course of the experiment, feces produced by *C. verrucosa* were easily identified because of their sausage-shape, while the deposits produced by *P. setosa* were rounded and smaller. Estimated BR and mass specific deposition rate (MSBR), when the ascidians were feeding on natural seston, was higher in *C. verrucosa* than in *P. setosa*

**Fig. 3** Assimilation efficiency (mean ± SD) under different diets (see Table 1). **a** *Laternula elliptica*. **b** *Cnemidocarpa verrucosa* (black bars) and *Pyrua setosa* (white bars)

(Table 5). Thus, the estimated total particle flux, POC and PON fluxes varied according to species and abundance in the different areas of Potter Cove (Table 6).

Discussion

Estimations of gut-residence time (GRT) depended on animal behavior. Clams that were fed, despite experimental condition, produced colored feces in less than 24 h while ascidians did not. Ascidians were generally very sensitive to water movements, and closed their siphons when disturbed. To estimate AE, GRT was assumed to be approximately 24 h as was previously stated for other ascidian species (Klumpp 1984; Robbins 1985a). Suspension feeders

Table 4 *C. verrucosa* and *P. setosa* (pooled data). Regression analysis between biodeposition rate (BR) and variables like animal dry mass and seston composition (SPM, Chl a and C:N ratio), natural seston

	<i>n</i>	<i>F</i>	<i>P</i>	<i>r</i> ² (%)
Animal dry mass (g)	11	0.13	0.72	1.41
SPM (mg l ⁻¹)	12	0.15	0.7	1.49
Chl a (µg l ⁻¹)	12	0.05	0.82	0.51
C:N	12	0.26	0.62	2.5

Table 5 Biodeposition rate (BR), mass specific biodeposition rate (MSBR), POC and PON (% from dry mass of feces) under natural seston (mean ± SD) for *C. verrucosa* and *P. setosa*

	<i>C. verrucosa</i>	<i>P. setosa</i>
BR (mg specimen ⁻¹ day ⁻¹)	10.9 ± 2.6	5.4 ± 0.3
MSBR (mg gDM ⁻¹ day ⁻¹)	6.4 ± 2.7	3.8 ± 2.2
POC (%)	4.6 ± 1.4	2.3 ± 1.2
PON (%)	0.5 ± 0.1	0.3 ± 0.1

Table 6 Estimated particle, POC and PON fluxes by *C. verrucosa* and *P. setosa* in different areas of Potter Cove, at a depth of 30 m

	<i>C. verrucosa</i>			<i>P. setosa</i>		
	E1	E2	E3	E1	E2	E3
Animal abundance (ind m ⁻²)	1.8	1.9	3.6	0.9	–	0.1
Animal biomass (gDM m ⁻²)	3.51	3.7	7	1	–	0.12
Total particle flux (mgDM m ⁻² d ⁻¹)	22.5	23.7	44.9	3.9	–	0.44
POC flux (mg m ⁻² d ⁻¹)	1.03	1.09	2.07	0.09	–	0.01
PON flux (mg m ⁻² d ⁻¹)	0.11	0.12	0.22	0.012	–	0.001

can feed on a broad spectrum of prey items, from bacteria to zooplankton, and certain species may change their diet when different food becomes available (Gili et al. 2001). This trophic plasticity may represent an advantage, because it might attenuate the effects of seasonal fluctuations on the availability of different resources in the water column. In experimental conditions in other studies, AE varied according to the diets offered. Monoculture was efficiently assimilated by ascidians, up to 92% (Fiala-Médioni 1974). Other particle types, i.e. natural seston, were also efficiently assimilated. Navarro and Thompson (1996) estimated 77% and Tito de Morais and Fiala-Médioni (1985) up to 95%. Kelp detritus was also assimilated at about 40%, in both the mussel *Choromytilus meridionalis* (Griffiths 1980) and the ascidian *Pyura stolonifera* (Klumpp 1984). Although in the present study high values of AE for ascidians were estimated from natural seston, no significant differences were observed between diets in the three test species. Macroalgal diets were assimilated at least at a mean of 26% efficiency,

reinforcing the idea that the filter-feeding community may use kelp detritus as alternative food source in the impoverished phytoplankton environment of Potter Cove. Gut content analyses carried out in specimens of *C. verrucosa*, immediately fixed after sampling, revealed the presence of recognizable macroalgal fragments which was one of the most important components, as well as minute particles less than 5 µm in size, probably bacteria (Tatián et al. 2004). Although with less food value than fresh material, decaying macroalgal detritus as part of the bacterial loop can be a potential food source (Tenore et al. 1982; Albertelli et al. 1998; Sigsgaard et al. 2003). Bacteria represent a nitrogen source of comparable importance to phytoplankton (Seiderer and Newell 1985), and decaying algal particles would have significant numbers of bound bacteria. The fatty acids characterising the organic material in sediments from Potter Cove were odd-chain and branched components typical for bacteria and their degradation products (Graeve et al. 2007). These bacteria colonize diverse substrates in the sediments that comprise deposited material from the water column (phytoplankton, fecal pellets), benthic microalgae and macroalgal detritus carried by currents.

Small amounts of odd-chain fatty acids were also measured in *L. elliptica* reflecting ingestion of the highly degraded organic matter from the sediment which might be taken up after resuspension into the water column (Graeve et al. 2007). Feeding depends on seston quality: in the ascidian *P. stolonifera*, particles >65 µm are rejected (Klumpp 1984). Minimum particle size for maximal retention efficiencies measured in four solitary ascidian species from Potter Cove were 2–6.5 µm (Kowalke 1999), but no data are available for maximum particle size. The effect of particle size in the AE of the three species studied seems to be only important when particles are larger than previously estimated. As mentioned above, *P. stolonifera* showed a particle effect with particles >65 µm, and the species studied at Potter Cove showed a similar effect but at particle sizes of 125 and 250 µm, for *C. verrucosa* and *L. elliptica* respectively. As *P. setosa* did not show a decrease in AE under higher particle size, it is probable that particles smaller in size were also available since mesh size limited only the upper size in the provided diets. Refractory and/or inorganic material influences behavior of benthic organisms, and high inorganic loads (25 mg l⁻¹, 3% OM) results in rejection (Klumpp 1984). Likewise, ingestion of this material results in a lower net intake of high quality organic material, producing a decrease of growth (Wiekling and Krönke 2005). According to Armsworthy et al. (2001), AE decreased significantly from 46 to 23% when adding up to 46 mg l⁻¹ sediment to the natural seston; however, such high concentrations were not measured in Potter Cove. Water pumped from the surface of the cove used to fill aquaria in experiments of natural seston (diet 5) reached up

Table 7 C:N ratio in feces produced by different suspensivores under experimental conditions (natural seston)

	Taxon	C:N	Reference
<i>Crassostrea virginica</i>	Bivalve	5.3	Frankenberg and Smith 1967 (cit. Ahn 1993)
<i>Geukensia demissa</i>	Bivalve	6.9	Kraeuter 1976 (cit. Ahn 1993)
<i>L. elliptica</i>	Bivalve	6.0 ± 1.1	Ahn (1993)
		5–7	Mercuri et al. (2007)
<i>Adamussium colbecki</i>	Bivalve	5.13	Chiantore et al. (1998)
<i>Halocynthia pyriformis</i>	Ascidian	13.6 ± 1.1	Tatián et al. (2003)
<i>Styela rustica</i>	Ascidian	8 ± 0.7	Tatián et al. (2003)
<i>C. verrucosa</i>	Ascidian	9.7 ± 2	This study
<i>P. setosa</i>	Ascidian	7.9 ± 2.1	This study

to 8.6 mg l⁻¹ SPM in mean, mostly inorganic particles (Table 3). Total SPM values close to the bottom, measured at 30 m, were even lower during a year-round period, with mean values of 3–6.5 mg l⁻¹ (Tatián et al. 2002). These values are similar to concentrations of the experimental macroalgal/diatomaceous earth diets (Table 3). Nevertheless, we need to emphasize that water samples were usually taken under calm weather conditions. Higher values are possible during storms since winds and storms can cause resuspension of bottom sediments up to a depth of 30 m (Schloss et al. 1999).

Low retention performance measured in filter feeding species from Potter Cove reduces the risk of clogging their filtering structure, as suggested by Kowalke (1999). This adaptation can help during stormy days, when resuspension increases SPM which consists mostly of inorganic particles. At low seston concentration (approximately 4 mg l⁻¹ in all macroalgal diets) and under higher inorganic percentage, the AE did not decrease significantly in the three species studied. Arctic communities near glacier bays are dominated by small-bodied mobile surface-deposit feeders, and are characterized by low biomass, low species richness and low species diversity (Wlodarska-Kowalczyk et al. 2005). While benthic communities in Potter Cove are dominated by filter-feeders, secondary production and diversity are comparatively high in relation to other areas (Sahade et al. 1998), suggesting that the impact of sedimentation is still low or that the resident species can cope well with the sedimentation rates. However, the Antarctic Peninsula is under a rapid warming process, faster than other regions of the world, and the retreat of glaciers observed in the area (Cook et al. 2005) produces an increase in sediment load in the coastal systems. Since a shift in benthic communities of Potter Cove has been observed in the last 10 years (Sahade et al. 2007), it is necessary to determine how these communities might be affected by a higher sedimentation.

Filter-feeding strategy is successful within inner Potter Cove, as indicated by the dominance of clams and ascidians (Sahade et al. 1998). Abundance and capacity of these species

to filter water seems to be important in pelagic–benthic coupling in the area. The biodeposits (feces and pseudofeces) enhance particle flux that nourishes the associated benthic fauna. According to mathematical models proposed by Momo et al. (2002), the biodeposition rate (BR) of the bivalve *L. elliptica* at Potter Cove is even higher in winter than in summer. *L. elliptica* population maintains a stable biomass on a yearly basis; although the number of individuals per square meter decreases throughout the year until the next recruitment event (winter), biomass per square meter remains roughly constant because the mortality is compensated by the individual growth. The MSBR estimated for *L. elliptica* (natural seston) at the nearby Marian Cove, on King George Island was 0.26–2.17 mg DMg WM⁻¹ d⁻¹ (Ahn 1993). However, she found that in *L. elliptica*, MSBR decreased with an increase in body mass. In the case of ascidians, BR equals the mean feces production rate because of the absence of pseudofeces. Feces production was 50% higher in *C. verrucosa* than in *P. setosa* (Table 5). Pooled data for *C. verrucosa* and *P. setosa* showed that BR was not related to body mass and seston condition (SPM, Chl a, C:N) during the experiments (Table 4). This was probably because fluctuations of the different seston parameters measured during the experiment were not enough to reflect differences in the BR, or/and the number of test specimens was low (even pooling both ascidian species for regression analyses).

Particularly interesting are the POC and PON percentages from total dry mass of feces produced by the two ascidian species. Percentages of POC and PON in *C. verrucosa* duplicate those of *P. setosa* (Table 5), despite the lower C:N value of the former. Estimations of particle flux owing to deposition should consider abundance in a specific area; both species exhibited differences in abundance according to substrate type. Abundance is one order of magnitude higher in *C. verrucosa* than in *P. setosa* (Table 6). Estimated total particle flux owing to *C. verrucosa* is higher in particular sites of Potter Cove such as E3, characterized by moraine deposits. Carbon fluxes in the

studied ascidians (Table 7) are lower than the reported ones for *L. elliptica* ($0.095 \text{ g C m}^{-2} \text{ d}^{-1}$, Marian Cove, South Shetland, Antarctica) and also for species not present in Potter Cove such as *Mytilus* (from 2 up to $70 \text{ g C m}^{-2} \text{ d}^{-1}$) but similar to a sponge community ($0.002 \text{ g C m}^{-2} \text{ d}^{-1}$, Greenland–Norwegian Sea) (Ahn 1993; Graf and Rosenberg 1997). Considering that the bulk of the macrobenthic biomass at 30 m is represented by five solitary ascidian species (*Molgula pedunculata*, *C. verrucosa*, *Corella eumyota*, *Ascidia challengerii* and *P. setosa*) (Sahade et al. 1998), the overall effects of the total particle, POC and PON fluxes by the ascidian community should be more important than for only the two studied species. The C:N ratio estimated in feces is higher compared to *L. elliptica* and other filter-feeding bivalves (Table 7), suggesting a more effective assimilation of the nitrogen source from the natural seston by ascidians. Nitrogen is a major nutrient element that influences the cycling of organic material. Its relative contribution determines the quality of organic material available to the benthos (Wieking and Krönke 2005). Thus, ascidian feces appear not to be especially relevant as a nitrogen source for the benthic system, particularly as a food source for other fauna. Despite the relative lower quality, production of feces by ascidians and the carbon contained in it should be especially important to benthic fauna during low periods of primary production and water column stability, when particles available by different processes (advection, sedimentation and resuspension) are scarce.

Conclusion

Filter-feeders *L. elliptica*, *C. verrucosa* and *P. setosa* are capable of assimilating food sources such as macroalgal fragments of different sizes under a diverse particulate inorganic percentage within the water column. This plasticity is important for these species to survive in an area characterized by low phytoplankton production and high sedimentation caused by the influx of inorganic particles carried into the cove by ice melt runoff. Total particle flux and fluxes of POC and PON from ascidian feces vary between the two species considered, as well as their abundance in different areas of Potter Cove. Nevertheless, the C:N ratio in these feces is high as compared with other filter-feeding organisms, limiting its re-utilization by other benthic fauna because of its lower quality.

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