Supplement

Methods (Grazer exclusion experimental design)

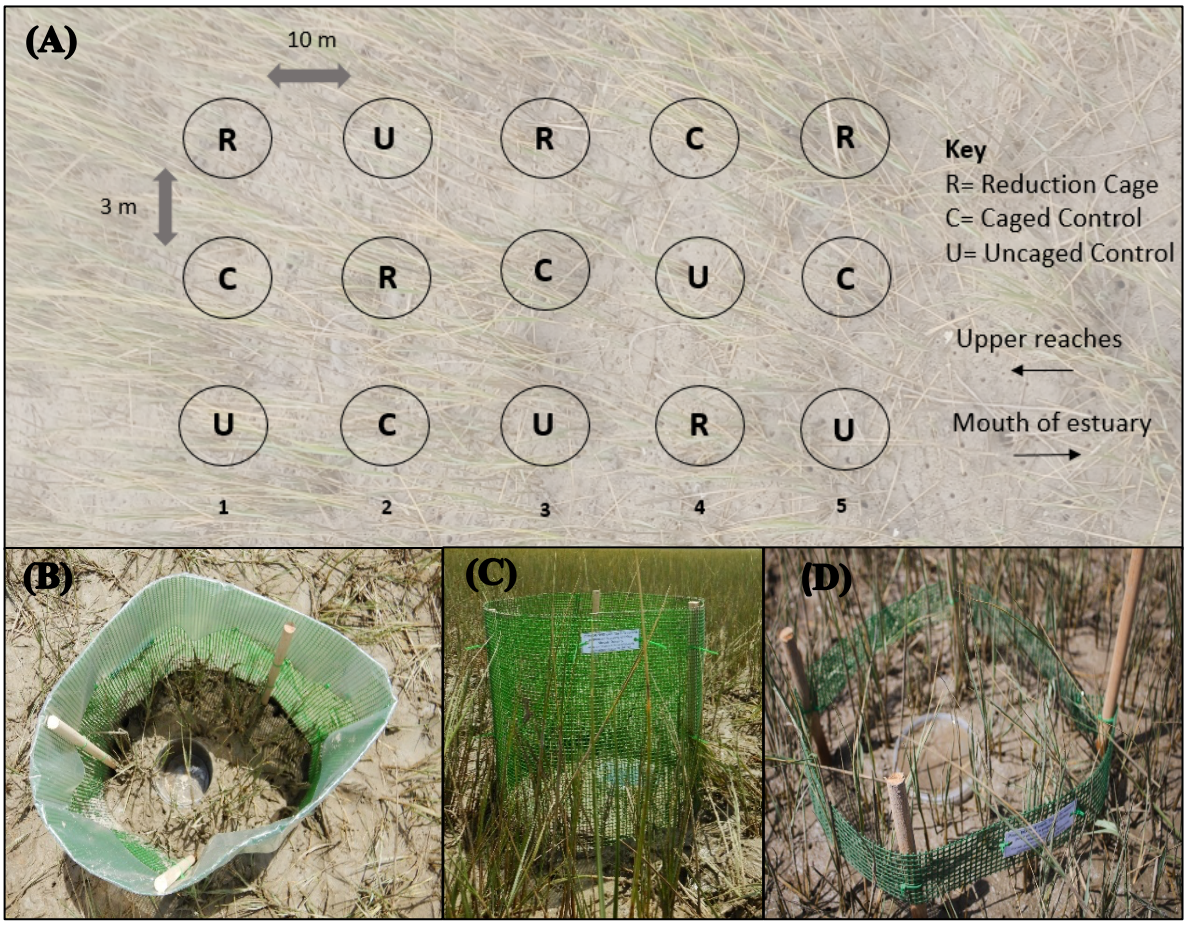

Figure S1: (A) The experimental design showing the randomised order of the treatment types and the distance between each treatment type and between transects. Transect 1 was on the far left towards the estuary upper reaches while Transect 5 was on the far right towards the estuary mouth, and the water's edge at the bottom. This experimental design was set up in the Kromme Estuary. Treatment types showing (B) the reduction cage, with a pit fall trap, (C) the caged control and (D) the uncaged control site. The caged control allows for crabs to enter the salt marsh area under investigation and therefore controls for crab effects when compared to the reduction cages, while the uncaged control site controls for cage effects.

Results (Grapsoid crab density in relation to salt marsh features)

Table S1: Summary of the salt marsh features measured (elevation, *Spartina maritima* stem density, *Spartina maritima* stem height, percentage vegetation cover, vegetation species richness), crab community (burrow density, burrow size, carapace width, carapace length) and sediment features (pH, redox potential: mV, moisture content (%), SOM (%), % clay, % sand, % silt) at three South African estuaries (Knysna, Kromme, Swartkops) in the months of September 2021 and April 2022 (mean ± SD). SOM (sediment organic matter); pH; mV (millivolts). The proportion of *Parasesarma catenatum* is compared to that of *Cyclograpsus punctatus*. The density of gastropods (*Assiminea* spp. primarily) as other potential grazers is also included.

Estuary	**Knysna**		**Kromme**		**Swartkops**	
Stage of growth season	**Beginning**	**End**	**Beginning**	**End**	**Beginning**	**End**
Elevation (m)	118.6 (± 19.5)		137.9 (± 19.3)		125.8 (± 15.9)	
Spartina Stem Density (n/m^2)	735 (± 478)	1382 (± 502)	1301 (± 388)	2251 (± 590)	918 (± 273)	3209 (± 884)
Spartina Stem Height (cm)	45.9 (±11.9)	54.0 (± 9.1)	46.5 (± 11.0)	45.4 (± 7.1)	46.9 (± 8.7)	53.0 (± 9.8)
% Vegetation Cover	54.9 (± 25.7)	83.9 (± 14.5)	48.8 (± 14.7)	68.6 (± 19.5)	44.3 (± 22.1)	63.3 (± 10.6)
Vegetation Species Richness	2 (± 1.1)	2 (± 0.8)	1 (± 0.8)	2 (± 0.5)	1 (± 0)	1 (± 0.6)
Burrow Density (n/m^2)	231 (± 167)	185 (± 113)	312 (± 143)	250 (± 91)	125 (± 101)	150 (± 117)
Burrow Size (mm)	7.2 (± 2.8)	8.1 (± 1.4)	5.7 (± 1.5)	8.4 (± 1.6)	6.7 (± 2.2)	6.8 (± 2.4)
Carapace Width (mm)	14.8 (± 4.9)	12.7 (± 4.5)	16.0 (± 3.2)	15.1 (± 3.2)	12.6 (± 3.2)	11.2 (± 2.3)
Carapace Length (mm)	12.1 (± 4.3)	10.2 (± 3.9)	12.9 (± 2.7)	12.4 (± 2.9)	10.0 (± 2.7)	8.8 (± 2.1)
Proportion *Parasesarma catenatum*	0.93 (n=232)	0.84 (n=267)	0.98 (n=215)	0.74 (n=266)	1.00 (n=226)	0.99 (n=215)
pH	6.6 (± 0.03)	6.7 (± 0.2)	6.6 (± 0.03)	6.8 (± 0.4)	6.7 (± 0.6)	6.7 (± 0.6)
Redox potential (mV)	142.0 (± 106.5)	68.1 (± 97.5)	32.1 (± 111.5)	159.1 (± 63.4)	34.3 (± 60.6)	13.1 (± 77.4)
Moisture Content (%)	8.4 (± 3.8)	7.3 (± 2.0)	8.6 (± 2.4)	7.2 (± 1.9)	12.2 (± 2.2)	10.5 (± 2.6)
SOM (%)	3.6 (± 3.4)	2.4 (± 1.7)	4.9 (± 2.1)	3.2 (± 1.2)	7.4 (± 1.9)	5.0 (± 2.3)
% Clay	17.2 (± 11.5)	10.6 (± 6.4)	12.0 (± 10.7)	24.0 (± 9.0)	24.8 (± 13.4)	44.9 (± 12.8)
% Sand	3.8 (± 2.5)	4.7 (± 3.0)	3.7 (± 2.1)	7.0 (± 4.8)	9.1 (± 2.6)	9.3 (± 3.3)
% Silt	79.0 (± 11.9)	84.7 (± 6.4)	84.4 (± 11.4)	69.0 (± 12.7)	66.1 (± 17.3)	45.8 (± 13.6)
Gastropod Density (n/m^2)	19 (± 59)	12 (± 45)	18 (± 95)	5 (± 16)	69 (± 277)	108 (± 359)

Table S2: Linear mixed effects model comparing the stem densities of *Spartina maritima* at three study sites (Knysna, Kromme, Swartkops). Season, site, burrow size, % sand and % silt were considered as the most-parsimonious predictors for the model, with the 'beginning of the growth season' and 'Knysna' being the reference categories to which the t-statistic and coefficients (C) are compared. Predictor variables overall are compared using the F-statistic. Significant parameters are indicated in bold.

	C± SE	**t**	**F**	**P**
Season	—	—	96.79	**< 0.001**
End	88.83 (± 9.53)	9.32	—	**<0.001**
Site	—	—	20.90	**< 0.001**
Kromme Estuary	39.76 (± 10.83)	3.67	—	**< 0.001**
Swartkops Estuary	68.21 (± 14.68)	4.65	—	**< 0.001**
Burrow Density	0.05 (± 0.04)	1.50	—	0.14
Burrow Size	-4.46 (± 2.03)	-2.20	—	**0.03**
% Sand	-4.00 (± 1.43)	-2.80	—	**0.007**
% Silt	-0.55 (± 0.36)	-1.53	—	0.13

Table S3: Linear mixed effects model comparing the stem height of *Spartina maritima* at Knysna, Kromme and Swartkops estuaries. Season, site, burrow size, % sand and % silt were considered as the most-parsimonious predictors for the model, with 'the beginning of the growth season', and 'Knysna" forming the reference categories to which the t-statistic and coefficients (C) are compared. The F-statistic is used to compare the predictor variables overall. Significant parameters are indicated in bold.

	C± SE	**t**	**F**	**P**
Season	—	—	5.80	**0.02**
End	3.08 (± 2.17)	1.42	—	0.16
Site	—	—	1.61	0.19
Kromme Estuary	-2.87 (± 2.60)	-1.10	—	0.27
Swartkops Estuary	-0.47 (± 2.96)	-0.16	—	0.87
Burrow Density	-0.007 (± 0.008)	-0.87	—	0.38
mV	-0.03 (± 0.01)	-3.08	—	**0.003**
SOM	-0.86 (± 0.47)	-1.83	—	0.07

Table S4: Linear mixed effects model comparing burrow density across three estuaries (Knysna, Kromme, Swartkops), compared to the most-parsimonious predictors of season and site, redox: mV, SOM, % sand and % silt. For the categorical predictors, 'the beginning of the growth season', and 'Knysna" were the reference categories to which the t-statistic and coefficients (C) are compared. The F-statistic is used to compare the predictor variables overall. Significant parameters are indicated in bold.

	C± SE	t	F	P
Season	—	—	1.00	0.32
End	-62.70 (± 30.69)	-2.04	—	**0.04**
Site	—	—	10.07	**0.0001**
Kromme Estuary	65.86 (± 33.31)	1.98	—	0.05
Swartkops Estuary	-132.85 (± 45.97)	-2.89	—	**0.005**
mV	-0.22 (± 0.14)	-1.54	—	0.13
SOM	-8.05 (± 6.61)	-1.22	—	0.23
% Sand	5.56 (± 4.75)	1.17	—	0.25
% Silt	-1.64 (± 1.12)	-1.47	—	0.15

Results (Diet of grapsoid crabs)

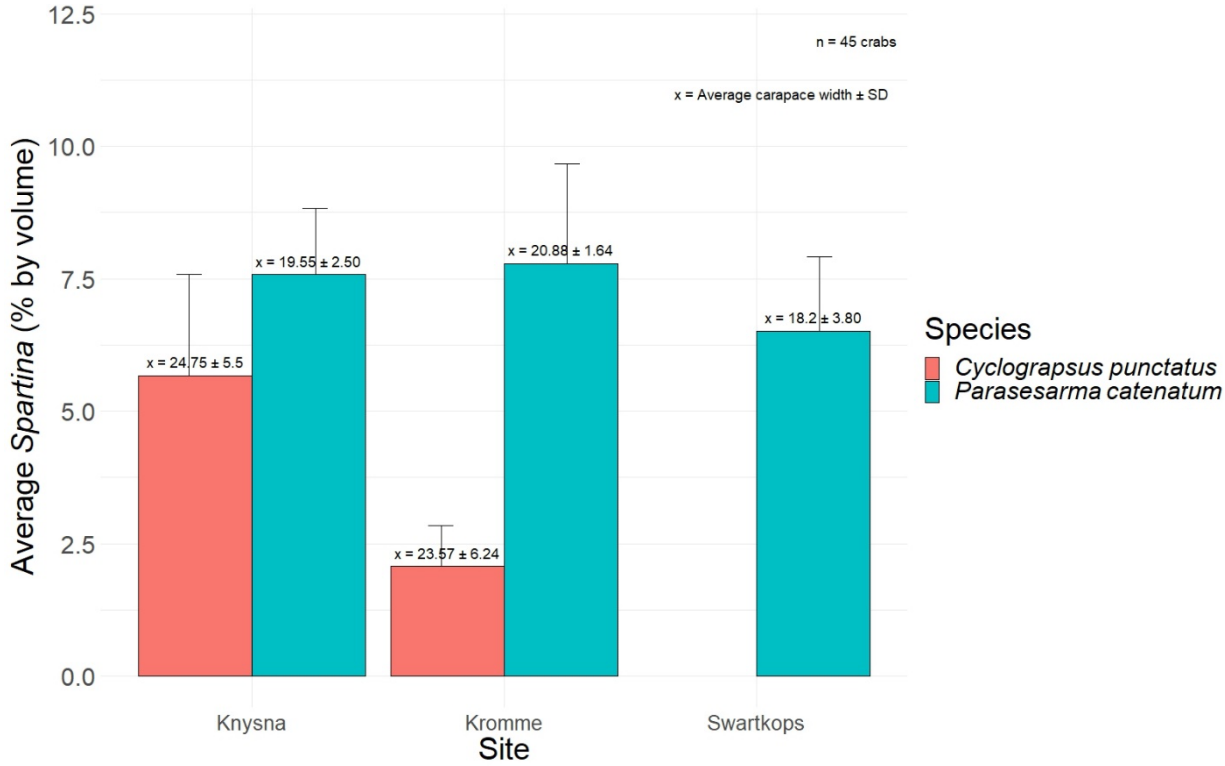

Figure S2: Average *Spartina maritima* (% by volume) (± SE) from the gut content of two species of grapsoid crabs (*Cyclograpsus punctatus, Parasesarma catenatum*). Cyclograpsus punctatus was not sampled in the Swartkops**.**

Table S5: Multifactorial linear model comparing the gut content in terms of % *Spartina maritima* by volume of two species of grapsoid crabs collected at three South African estuaries (Knysna, Kromme, Swartkops) during September 2021. Species and site form the predictor variables of the model, with 'Cyclograpsus punctatus' and 'Knysna' being the reference categories to which the t-statistic and coefficients (C) are compared. Predictor variables overall are compared using the F-statistic. Significant parameters are indicated in bold.

	C(± SE)	**t**	**F**	**P**
Species	—	—	6.53	**< 0.05**
Parasesarma catenatum	4.04 (± 1.65)	2.45	—	**< 0.05**
Site	—	—	0.57	0.57
Kromme Estuary	-1.14 (± 1.59)	-0.72	—	0.48
Swartkops Estuary	-1.63 (± 1.62)	-1.01	—	0.32

Table S6: Multifactorial linear model comparing $\delta^{13}C$ stable isotope signatures of different food sources consumed by two species of grapsoid crabs collected at three South African estuaries (Knysna, Kromme, Swartkops). Sampling took place in September 2021. Source, species and site form the predictor variables of the model, with 'Swartkops', '*Cyclograpsus punctatus*' and 'microphytobenthos' being the reference categories to which the t-statistic and coefficients (C) are compared. Predictor variables overall are compared using the F-statistic. Significant parameters are indicated in bold.

	C(± SE)	**t**	**F**	**P**
Source	—	—	36.10	**< 0.01**
Epiphytes	0.14 (± 0.03)	4.22	—	**< 0.001**
Spartina	0.16 (± 0.03)	4.80	—	**< 0.001**
Sediment	0.15 (± 0.03)	4.65	—	**< 0.001**
Zostera	0.05 (± 0.03)	1.59	—	0.13
Detritus	0.01 (± 0.03)	0.38	—	0.71
Species	—	—	0.00	0.99
Parasesarma catenatum	-0.04 (± 0.03)	-1.17	—	0.26
Site	—	—	0.00	1.00
Kromme Estuary	-0.000042 (± 0.02)	-0.0020	—	1.00
Knysna Estuary	0.000042 (± 0.02)	0.002	—	1.00
Source:Species	—	—	4.47	**< 0.01**
Parasesarma catenatum: Epiphytes	0.09 (± 0.04)	2.10	—	0.05
Parasesarma catenatum: Spartina	0.08 (± 0.04)	1.92	—	0.07
Parasesarma catenatum: Sediment	-0.05 (± 0.04)	-1.17	—	0.26
Parasesarma catenatum: Zostera	0.10 (± 0.04)	2.43	—	**0.03**
Parasesarma catenatum: Detritus	-0.01 (± 0.04)	-0.23	—	0.82

Table S7: The %C and %N for the potential food sources consumed by *Cyclograpsus punctatus* and *Parasesarma catenatum*, two species of grapsoid crabs, from three South African estuaries (Knysna, Kromme, Swartkops). The carbon to nitrogen ratios are also provided.

Site	Food Source	%C (± SD)	%N (± SD)	C:N
Knysna	Epiphytes	2.43 (± 0.002)	0.38 (± 0.0005)	7.47
	Spartina	0.38 (± 0.04)	0.01 (± 0.004)	37.52
	Sediment	1.34 (± 0.005)	0.14 (± 0.0004)	11.15
	Zostera	37.34 (± 0.01)	2.93 (± 0.005)	15.20
	Detritus	1.27 (± 0.0009)	0.27 (± 0.0001)	5.61
	Microphytobenthos	0.04 (± 0.006)	0.002 (± 0.0002)	18.82
Kromme	Epiphytes	0.04 (± 0.008)	0.01 (± 0.0006)	8.95
	Spartina	0.38 (± 0.03)	0.01 (± 0.005)	43.98
	Sediment	2.67 (± 0.01)	0.11 (± 0.001)	41.66
	Zostera	36.10 (± 0.02)	2.73 (± 0.004)	15.44
	Detritus	0.01 (± 0.0003)	0.003 (± 0.00002)	6.11
	Microphytobenthos	0.04 (± 0.007)	0.002 (± 0.0003)	19.04
Swartkops	Epiphytes	0.05 (± 0.007)	0.01 (± 0.0008)	7.52
	Spartina	0.34 (± 0.05)	0.01 (± 0.002)	39.45
	Sediment	2.41 (± 0.004)	0.18 (± 0.001)	15.92
	Zostera	36.37 (± 0.02)	3.04 (± 0.004)	14.10
	Detritus	0.01 (± 0.0002)	0.003 (± 0.0002)	5.12
	Microphytobenthos	3.85 (± 0.003)	0.23 (± 0.0002)	19.18

Results (Grazing impact of grapsoid crabs)

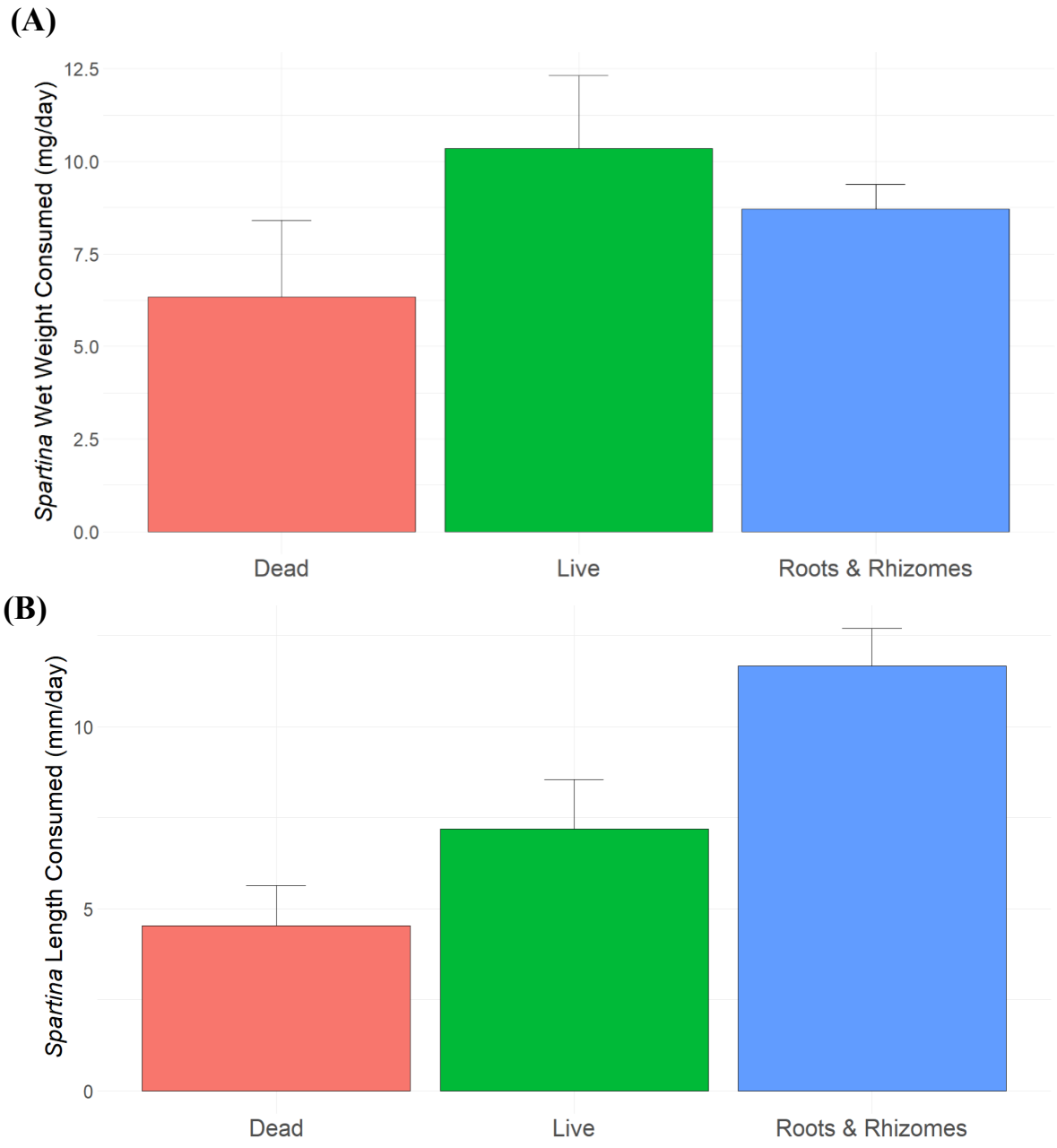

Figure S3: The average amount of *Spartina maritima* consumed, in terms of wet weight (mg/day) (± SE) (A) and the average length (mm) of *Spartina maritima* consumed per day (± SE) (B), by both *Parasesarma catenatum* and *Cyclograpsus punctatus.* Three components of *S. maritima* were tested as sources of food (dead, live, roots and rhizomes).

Table S8: Linear mixed effects model comparing the wet weight consumed per day for different *Spartina maritima* components (dead, live, roots and rhizomes), taking sex and species into account. The model's predictor variables include sex, food source and species, with 'female', 'dead *Spartina*' and '*Cyclograpsus punctatus*' forming the reference categories to which the t-statistic and coefficients (C) are compared. Predictor variables overall are compared using F-statistics. Significant parameters are indicated in bold.

	C±SE	**t**	**F**	**P**
Sex	—	—	4.79	**0.03**
Male	3.16 (±3.86)	1.16	—	0.42
Source	—	—	1.61	0.21
Live *Spartina*	7.28 (±3.77)	1.93	—	0.58
Roots & Rhizomes of *Spartina*	5.11 (±3.59)	1.46	—	0.15
Species	—	—	0.12	0.12
Parasesarma catenatum	2.25 (±4.29)	0.92	—	0.36
Carapace Length	0.69 (±0.50)	1.57	—	0.12
Sex: Source	—	—	0.14	0.87
Male: Live *Spartina*	1.39 (±4.69)	0.29	—	0.77
Male: Roots & Rhizomes of *Spartina*	-2.07 (±4.94)	-0.38	—	0.70
Source: Species	—	—	1.63	0.20
Live *Spartina*: *Parasesarma catenatum*	-8.46 (±4.72)	-1.78	—	0.08
Roots & Rhizomes of *Spartina*: *Parasesarma catenatum*	-2.87 (±4.89)	-0.63	—	0.53
Sex:Species	—	—	0.17	0.68
Male: *Parasesarma catenatum*	1.69 (±4.15)	0.41	—	0.68

Table S9: Linear mixed effects model comparing the length of *Spartina maritima* components (live, dead, roots and rhizomes) consumed per day, taking sex and species into account. The model's predictor variables include sex, food source and species, with 'female', 'dead *Spartina*' and '*Cyclograpsus punctatus*' forming the reference categories to which the t- statistic and coefficients (C) are compared. Predictor variables overall are compared using F-statistics. Significant parameters are indicated in bold.

	C±SE	**t**	**F**	**P**
Sex	—	—	1.45	0.23
Male	-0.83 (±2.67)	-0.31	—	0.60
Source	—	—	10.87	**0.0001**
Live *Spartina*	2.41 (±2.61)	0.92	—	0.39
Roots & Rhizomes of *Spartina*	7.11 (±2.49)	2.86	—	**< 0.001**
Species	—	—	8.38	**0.005**
Parasesarma catenatum	-4.40 (±2.97)	-1.48	—	0.51
Carapace Length	0.17 (±0.34)	0.49	—	0.31
Sex: Source	—	—	0.28	0.76
Male: Live *Spartina*	2.92 (±3.25)	0.9	—	0.39
Male: Roots & Rhizomes of *Spartina*	0.78 (±3.42)	0.23	—	0.70
Source: Species	—	—	0.26	0.77
Live *Spartina*: *Parasesarma catenatum*	-2.56 (±3.27)	-0.78	—	0.48
Roots & Rhizomes of *Spartina*: *Parasesarma catenatum*	-0.67 (±3.39)	-0.20	—	0.72
Sex: Species	—	—	2.66	0.11
Male: *Parasesarma catenatum*	4.68 (±3.87)	1.63	—	0.11

Table S10: Summary of the salt marsh features (elevation, *Spartina maritima* stem density, Spartina maritima stem height, percentage vegetation cover, aboveground biomass), crab community (burrow density as an indicator of crab density, burrow size) and sediment features (SOM (%), moisture content (%), pH, redox potential (mV), % clay, % sand, % silt) at the Kromme Estuary in the months November 2021 to March 2022 (mean ± SD). SOM (sediment organic matter), for the different treatment types (reduction cage, caged control, uncaged control). The density of gastropods (predominantly *Assiminea* spp.) as other potential grazers is also included.

Treatment Type	**Crab reduction Cage**		**Caged control**		**Uncaged Control**	
Stage of experiment	Start	End	Start	End	Start	End
Elevation	81.0 (±6.4)		78.0 (±6.0)		83.2 (±9.0)	
Spartina stem density (n/m^2)	1028 (±228)	743 (±126)	758 (±313)	676 (±116)	1019 (±228)	547 (±253)
Spartina stem height (cm)	16.8 (±2.6)	21.8 (±1.8)	17.3 (±3.3)	21.8 (±3.1)	17.2 (±1.2)	22.5 (±1.9)
% Vegetation cover	10 (±5.0)	21 (±13.9)	6 (±2.2)	14 (±4.1)	10 (±3.5)	17 (±2.7)
Aboveground *Spartina* biomass (g/m^2)	3436 (±1530)	4330 (±2727)	2092 (±1279)	1731 (±1779)	3280 (±1001)	3823 (±852)
Burrow density (n/m^2)	317 (±118)	290 (±107)	347 (±77)	395 (±113)	447 (±86)	434 (±57)
Burrow size (mm)	5.7 (±0.8)	6.46 (±0.9)	6.1 (±0.4)	7.48 (±1.3)	6.4 (±0.8)	8.72 (±2.9)
SOM (%)	3.7 (±0.3)	3.5 (±0.6)	4.1 (±0.3)	3.5 (±0.7)	3.9 (±0.7)	3.7 (±0.2)
Moisture content (%)	8.87 (±0.9)	7.65 (±1.4)	8.93 (±0.6)	7.78 (±1.0)	8.69 (±0.9)	9.17 (±0.7)
pH	6.6 (±0.02)	6.3 (±0.7)	6.6 (±0.01)	6.2 (±0.8)	6.6 (±0.02)	6.6 (±0.1)
Redox potential (mV)	67.4 (±66.0)	16.2 (±140.5)	66.8 (±19.2)	34.2 (±93.1)	-5.6 (±74.9)	-29.6 (±74.8)
% Clay	18.8 (±10.3)	33.9 (±10.5)	16.9 (±6.3)	35.5 (±18.8)	23.5 (±7.4)	31.9 (±9.4)
% Sand	7.7 (±3.2)	7.3 (±1.6)	7.7 (±4.6)	6.8 (±2.05)	9.6 (±5.0)	7.4 (±2.9)
% Silt	73.9 (±10.01)	58.8 (±10.9)	75.4 (±8.9)	57.7 (±17.7)	66.9 (±11.8)	60.7 (±9.2)
Gastropod density (n/m^2)	40 (±44)	159 (±119)	16 (±14)	151 (±118)	56 (±55)	167 (±132)

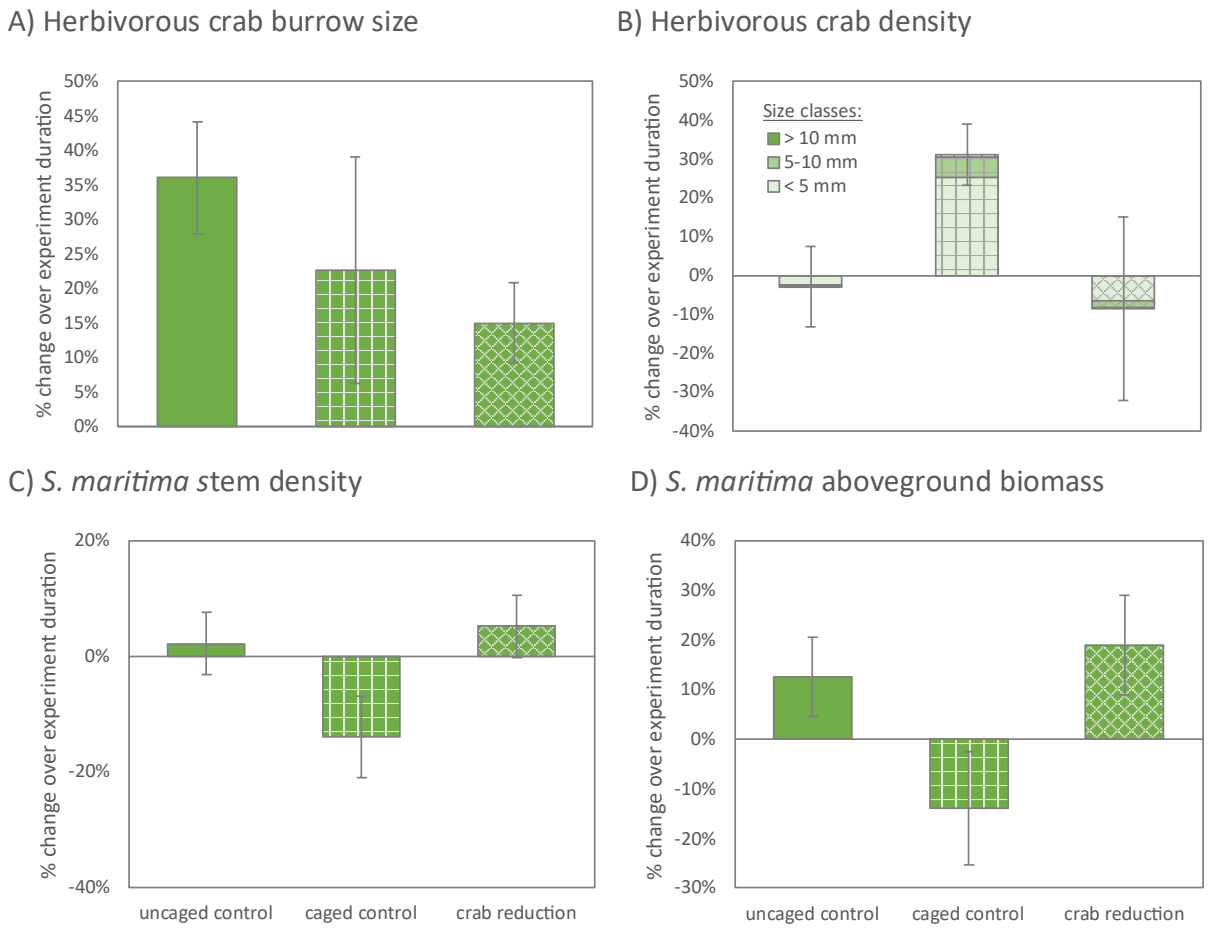

Figure S4: Percentage change in metrics of herbivorous grapsoid crab burrow sizes (A) and density (B) as well as associated *Spartina maritima* stem density (C) and aboveground biomass (D) over the course of the *S. maritima* growth season at the Kromme Estuary, South Africa, from November 2021 to March 2022. Data are presented as mean ±SE (n = 5 per treatment). The 'uncaged control' represents open plots (open bars), the 'caged control' represents plots with cages that allowed free movement of crabs (laterally hatched bars), and the 'crab reduction' represents plots with cages that excluded large crabs and reduced overall crab abundance using pitfall traps (diagonally hatched bars). The crab density figure (panel B) is differentiated according to density of burrows per size class (diameter).

Table S11: Linear mixed effects model comparing salt marsh features for the different treatment types (uncaged control, reduction cage, caged control) at the Kromme Estuary where grapsoid crab impact was manipulated from November 2021 to March 2022. Separate models were run for *Spartina maritima* stem density, *Spartina maritima* stem height, percentage vegetation cover, sediment organic matter (SOM), moisture content (%), redox potential (mV) and % silt, with treatment type being the predictor variable. Significant parameters are indicated in bold and those where $0.05 \leq P < 0.10$ in italics.

	Treatment	**C±SE**	**F**	**t**	**P**
Burrow size	Overall	—	0.28	—	0.764
	caged control vs uncaged control	-0.004 ± 0.006	—	-0.63	0.546
	crab reduction vs uncaged control	0.0002 ± 0.006	—	0.03	0.978
	caged control vs crab reduction	-0.004 ± 0.006	—	-0.66	0.528
Spartina Stem Density	Overall	—	4.17	—	*0.058*
	caged control vs uncaged control	0.03 ± 0.07	—	0.41	0.690
	crab reduction vs uncaged control	-0.16 ± 0.07	—	-2.27	*0.053*
	caged control vs crab reduction	-0.19 ± 0.07	—	-2.68	**0.028**
Spartina Stem Height	Overall	—	0.73	—	0.513
	caged control vs uncaged control	0.008 ± 0.009	—	0.86	0.417
	crab reduction vs uncaged control	-0.003 ± 0.009	—	-0.31	0.766
	caged control vs crab reduction	-0.010 ± 0.009	—	-1.16	0.278
Spartina Aboveground Biomass	Overall	—	3.47	—	*0.082*
	caged control vs uncaged control	-0.0003 ± 0.014	—	-0.02	0.984
	crab reduction vs uncaged control	-0.033 ± 0.014	—	-2.29	*0.051*
	caged control vs crab reduction	-0.032 ± 0.014	—	-2.27	*0.053*
% Vegetation Cover	Overall	—	0.97	—	0.420
	caged control vs uncaged control	-0.04 ± 0.04	—	-1.01	0.343
	crab reduction vs uncaged control	-0.05 ± 0.04	—	-1.34	0.219
	caged control vs crab reduction	-0.01 ± 0.04	—	-0.33	0.752
SOM	Overall	—	0.56	—	0.591
	caged control vs uncaged control	0.01 ± 0.45	—	0.02	0.987
	crab reduction vs uncaged control	-0.41 ± 0.45	—	-0.91	0.390
	caged control vs crab reduction	-0.42 ± 0.45	—	-0.93	0.381
Moisture Content (%)	Overall	—	4.80	—	**0.043**
	caged control vs uncaged control	-1.70 ± 0.62	—	-2.73	**0.026**
	crab reduction vs uncaged control	-1.63 ± 0.62	—	-2.63	**0.030**
	caged control vs crab reduction	0.06 ± 0.62	—	0.10	0.920
Redox Potential (mV)	Overall	—	0.13	—	0.880
	caged control vs uncaged control	0.004 ± 0.406	—	0.01	0.992
	crab reduction vs uncaged control	0.181 ± 0.406	—	0.45	0.667
	caged control vs crab reduction	0.177 ± 0.406	—	0.44	0.675
% Silt	Overall	—	0.70	—	0.524
	caged control vs uncaged control	-8.87 ± 10.21	—	-0.87	0.411
	crab reduction vs uncaged control	-11.57 ± 10.21	—	-1.13	0.290
	caged control vs crab reduction	-2.70 ± 10.21	—	-0.26	0.798