Trophic structure and biomass distribution on two East Cape rocky shores

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The distribution and biomass of macrofauna and macroalgae is described for two intertidal rocky shores near Port Elizabeth. The sheltered shore supported more macrofauna species (67) than the exposed shore (61), mainly owing to greater habitat heterogeneity; of 88 species recorded, 40 (46%) were shared. The shores had 13 and 23 macroalgal species respectively, with 9 shared. Ash-free dry biomass averaged 26 g m^{-2} over 200 m on the sheltered shore and 56 g m^{-2} over 80 m on the exposed shore for macrofauna and 81 g m^{-2} and 77 g m^{-2} for the algae. Lower animal biomass values on the sheltered shore may partly have been due to exploitation. Macrobenthic biomass was partitioned as follows on the sheltered and exposed shores respectively: grazers 86% and 82%, filter feeders 8% and 13%, carnivores 4% and 5% and deposit feeders 2% and 0%. Species warranting further study are listed.

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Die verspreiding en biomassa van die makrofauna en makroalge word beskryf vir twee intergetyrotsstrande naby Port Elizabeth. Die beskutte strand het meer spesies (67) bevat as die blootgestelde strand (61), hoofsaaklik weens 'n meer komplekse fisiese habitat by die eersgenoemde strand. Van 88 spesies gevind op die twee strande was 40 (46%) gedeel. As-vryedroëbiomassawaardes was gemiddeld 26 g m^{-2} oor 200 m van die beskutte strand en 56 g m^{-2} oor 80 m van die blootgestelde strand vir makrofauna en 81 g m^{-2} en 77 g m^{-2} vir die alge. Die heelwat laer dierbiomassawaardes by die beskutte strand was miskien gedeeltelik te wyte aan eksploitasie. Makrobentiese biomassa word soos volg onderskeidelik op die beskutte en blootgstelde strande verdeel: weiers 86% en 82%, filtreervoeders 8% en 13%, karnivore 4% en 5% en neerslagvreters 2% en 0%. Spesies wat belangrik is vir verdere studie word genoem.

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Work on rocky shore ecology in South Africa has been concentrated in the Western Cape (Broekhuysen 1940; Davies 1966, 1967, 1969; Field & McFarlane 1968; Branch 1971, 1974a & b, 1975) and more recently in Natal (Jackson 1976, Berry pers. comm.). Other than the early qualitative surveys of the South African coastline by Stephenson, Stephenson & Bright (1938) no work has been published on intertidal rocky shore macrofauna in the Eastern Cape Province. Newman (1969) collected *Haliotis* in the shallow subtidal in this area, van Driel (1978) studied the ascidian *Pyura* and its associated fauna, also in the shallow subtidal, and Beckley & McLachlan (1979, 1980) have investigated the algal epifauna of St Croix Island.

The aim of the present study was to provide baseline information on the composition and biomass of intertidal macrofauna and macroalgae on two representative East Cape rocky shores.

Study sites

Most of the coastlines of Algoa Bay and St Francis Bay consist of sandy beaches with rocky shores restricted mainly to the area just west of, and including the Cape Receife headland. In this region two different but typical shore types were selected for study.

Flat Rocks is a sheltered shore just inside Algoa Bay. It has a gentle slope consisting of pebbles and boulders of Table Mountain sandstone in a matrix of calcareous sandstone (Stephenson *et al.* 1938). Sand occurs between the rocks and shallow intertidal pools are abundant. Wave action is light, upwelling is totally absent and the water is usually clouded with sand, bits of algae and detritus. This area is heavily patronised by anglers and the boulders are regularly overturned by bait gatherers.

Skoenmakerskop is a steep rugged shore directly exposed to heavy wave action and is typical of the coast west of Cape Receife. The rocks consist of highly folded and jointed quartzitic sandstones weathered into very jagged outcrops (Stephenson *et al.* 1938). Deep pools and gullies are present and the water is generally clearer than at Flat Rocks. Local upwellings sometimes occur here after easterly winds when the water temperature can drop by as much as 10 °C. Temperatures as low as 9 °C have been measured here when temperatures at Flat Rocks were 18 °C. There is little human interference in this area.

The annual temperature range in the shallows in Algoa Bay is 11 – 25 °C with monthly means of 21 °C in January and 15 °C in August. While this is representative of both sites, summer temperatures at Skoenmakerskop can drop below 11 °C during upwelling. The two study sites thus differ in terms of exposure to wave action, substrate, temperature changes and human interference.

Methods

Both shores were sampled by clearing 1-m² quadrats at intervals along transects from the top of the shore to 0,5 m below LWS (low water of spring tides) at Flat Rocks and to the top of a reef lying near LWS at Skoenmakerskop. At Flat Rocks, where there were no clear intertidal zones, samples were taken at regular horizontal intervals while at Skoenmakerskop sampling points were positioned so as to be representative of the different zones. Sponges, isopods, amphipods and seaweed epifauna were not collected because they were difficult to sample or were scarce. Where large populations of certain molluscs were encountered representative subsamples were taken. Algae were collected in a similar fashion but two years later than the initial survey.

In the laboratory all specimens were identified and their ash-free dry mass values determined from the difference in mass between drying at 100 °C and ashing at 480 °C after removal of shells in the case of molluscs.

Results and Discussion

The results are summarized in Table 1. Of 88 macrofauna species recorded, 67 were found at Flat Rocks and 61 at Skoenmakerskop with 40 (46%) shared. This does not include sponges, isopods, amphipods and epifauna. Of 32 algae recorded, nine were common to both shores. The distribution of biomass of the major trophic groups and algae, together with the intertidal profiles and sampling site positions, are given in Figures 1 and 2 for Flat Rocks and Skoenmakerskop respectively. The general distribution patterns on both shores were broadly similar to that recorded by McQuaid and Branch (in Newell 1979) at Dalebrook on the Cape Peninsula. Carnivores and deposit feeders were fairly evenly distributed, filter feeders and grazers tended to concentrate lower on the shore and algae were most abundant lower on the shore and in pools. Species numbers increased downshore and

Table 1 Summary of a survey of the macrofauna and macroalgae at Flat Rocks and Skoenmakerskop. Numbers of species and ash-free dry biomass per metre transect are given for algae and four feeding categories of macrofauna

	Flat Rocks		Skoenmakerskop	
Category	No. species	Biomass (g m⁻¹)	No. species	Biomass (g m⁻¹)
Algae	13	16 261	23	6 170
Grazers	30	4 467	26	3 683
Filter feeders	9	437	11	602
Deposit feeders	6	116	3	6
Carnivores	22	228	21	228
Total macrofauna	67	5 248	61	4 519

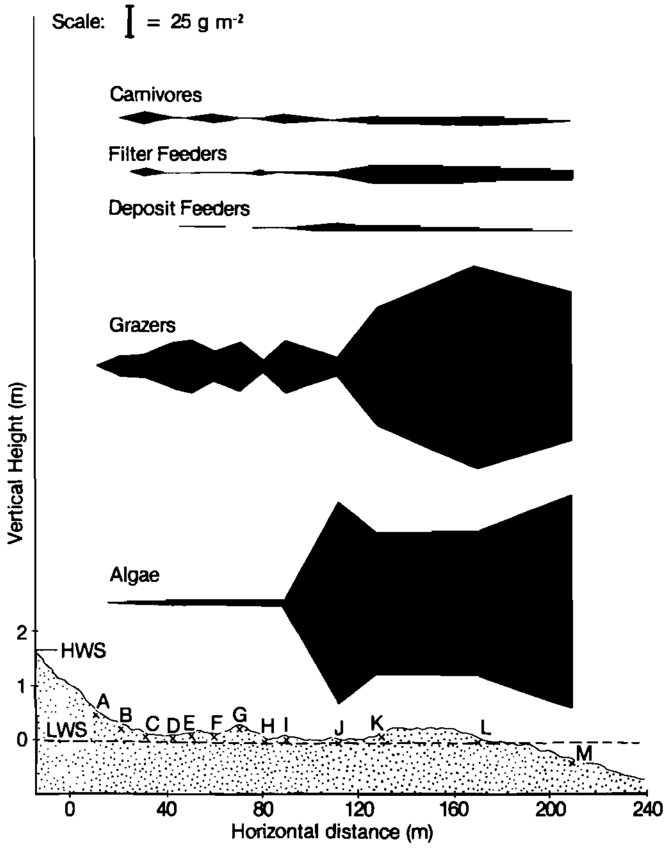

Fig. 1 Intertidal profile with sampling sites and biomass distribution at Flat Rocks.

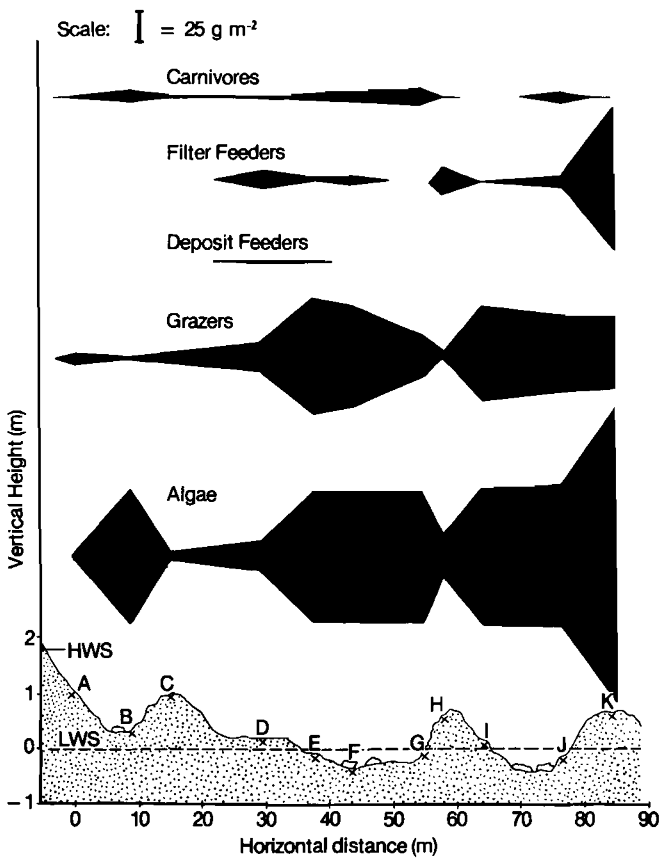

Fig. 2 Intertidal profile with sampling sites and biomass distribution at Skoenmakerskop.

in pools. It is not the purpose here to discuss details of zonation or distribution but rather general patterns and partitioning of biomass.

Total biomass increased towards the subtidal on both shores as inundation time, algal coverage and feeding times increased. At Skoenmakerskop the greater exposure to wave action and deeper pools blurred this effect slightly as biomass increased in each pool. Although the total transect length at Flat Rocks (200 m) was 2,5 times that at Skoenmakerskop (80 m) the total macrofauna biomass was only 1,15 times greater (5 248 g against 4 519 g) owing to lower biomass density (mean ≅ 26 g m^{-2} against ≅ 56 g m^{-2}). Effects of bait removal at Flat Rocks may be partly responsible for this lower biomass per unit area.

Of the nine dominant species in terms of biomass three were important on both shores: the alikreukel, *Turbo sarmaticus*, the urchin, *Parechinus angulosus* and the periwinkle, *Oxystele sinensis*. As adults of *T. sarmaticus* are almost totally removed from Flat Rocks, the nevertheless dominant position of this species suggests that it should make the biggest contribution to biomass in unexploited areas. At Flat Rocks it was second in importance behind *P. angulosus* while at Skoenmakerskop it was the most important species. *O. tigrina* and *Dinoplax gigas* dominated the 'middle' shore (sites C to I) and *D. gigas, O. sinensis, Cucumaria frauenfeldii, P. angulosus* and *T. sarmaticus* dominated the 'lower' shore (sites J to M) at Flat Rocks. The sparse population of the 'upper' shore (sites A and B) was dominated by *Siphonaria* spp., *Littorina knysnaensis* and *Oxystele variegata*.

At Skoenmakerskop the 'upper' shore (sites A and C) was dominated by *L. knysnaensis, Helcion pectunculus*, and *O. variegata*; the 'middle' shore (sites B, D – J) by *T. sarmaticus, P. angulosus, O. sinensis* and *Patella longicosta*; and the 'lower' shore (site K) by *Perna perna* and *Patella cochlear*. However, although site K was closest to the sea and subject to the strongest surge, it occupied a higher vertical position than the 'middle' shore sites which were mostly in pools.

Dominant algae were *Laurencia natalensis, Pterosiphonia cloiophylla, Lithothamnion* sp. and *Plocamium corallorhiza* at Flat Rocks and *Gelidium pristoides, Lithothamnion* sp., *Ralfsia verrucosa, Plocamium corallorhiza* and *Arthrocardia* sp. at Skoenmakerskop.

The difference in wave action between the two sites resulted in some differences in species composition. Flat Rocks for example had only three *Patella* spp. while Skoenmakerskop had seven. This genus typically occurs in exposed situations, especially *P. cochlear* (Branch 1971, Morgans 1958) which was absent at Flat Rocks. Similarily *P. perna*, which prefers exposed areas (Stephenson 1936), was important at Skoenmakerskop but absent at Flat Rocks. Besides wave action a further difference between these areas is the absence of deep pools at Flat Rocks. This is the reason for absence of most of the anemones (*Actinia equina, Bunodosoma capensis, Anthopleura michaelseni, Bunodactis reynaudi, Balanophyllia bonaespei*) at Flat Rocks.

Using the biomass data and assuming all animal species to conform to the four simplified feeding categories in Figures 1 and 2, a simple energy flow diagram has been constructed for each shore (Figures 3 & 4) using H.T. Odum's (1975) energy circuit language. This also assumes that 1 g ash-free dry mass is equivalent to 23,4 kJ for macrofauna (Winberg 1971) and 18,60 kJ for macroalgae (Beckley & McLachlan 1979).

On both shores the grazing food chain predominated, grazers accounting for 86% of the biomass at Flat Rocks and 82% at Skoenmakerskop. Filter feeders were more important on the exposed shore at Skoenmakerskop (13% against 8% of biomass) while deposit feeders, which made up 2% of biomass at Flat Rocks, were negligible (0,1%) at Skoenmakerskop because of the absence of sediments there. Benthic carnivores were equally important on the two shores, making up 4% and 5% of biomass.

The major carnivores were *Diogenes brevirostris* (1,4% of biomass) and *Pseudactinia varia* (1,1%) at Flat Rocks

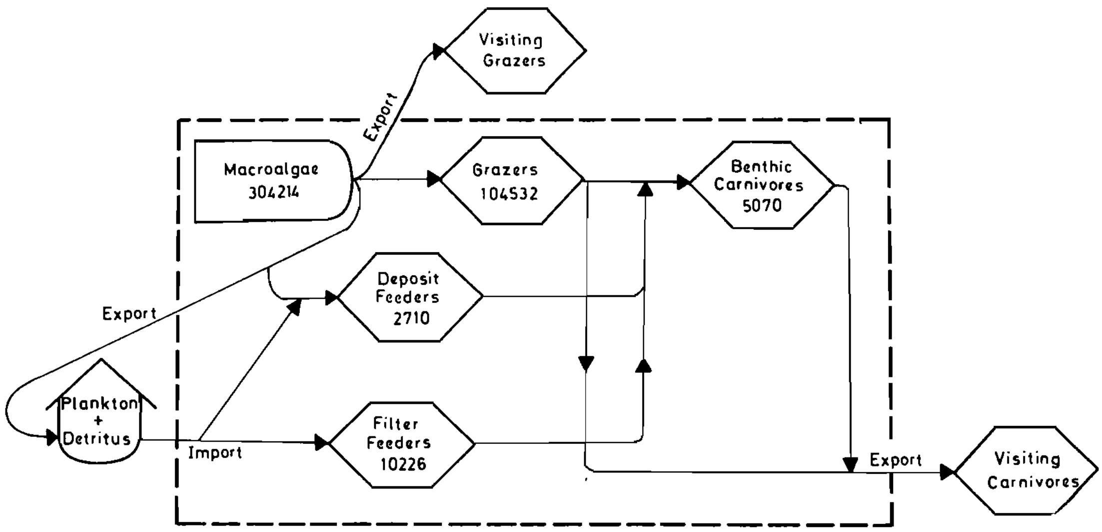

Fig. 3 Simplified energy circuit diagram for the intertidal zone at Flat Rocks. All values are in kJ/m shoreline.

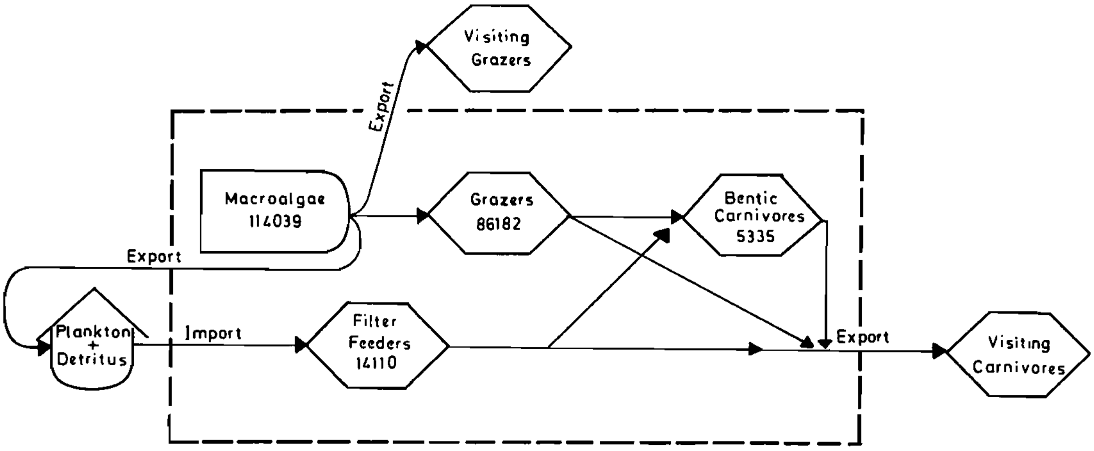

Fig. 4 Simplified energy circuit diagram for the intertidal zone at Skoenmakerskop. All values are in kJ/m shoreline.

and *Burnupena cincta* (2,5%) and *Marthasterias glacialis* (0,6%) at Skoenmakerskop. Dominant grazers were *T. sarmaticus* (22%), *P. angulosus* (30%) and *D. gigas* (17%) at Flat Rocks and *T. sarmaticus* (36%), *P. angulosus* (11%) and *O. sinensis* (13%) at Skoenmakerskop. *Cucumaria frauenfeldii* (6%) and *P. perna* (8%) were the dominant filter feeders on these two shores while *Piromus arenosus* (1,3%) was the dominant deposit feeder at Flat Rocks. As many of these species probably occupy more than one feeding category this picture is highly simplified. It does, however, give some indication of those species warranting further study. Of the above listed species *T. sarmaticus* (Lombard 1977), *P. angulosus* (Greenwood 1974) and *P. perna* (Berry 1978) have received attention in South Africa. Almost nothing is known of the remaining species. Further, very little information is available on feeding relations, food webs or macroalgal production.

The energy circuit diagrams presented here have ignored the contributions of algal epifauna which can be particularly important on the lower shore (Beckley & McLachlan 1979, 1980) and serve as a source of animal protein for grazers. Further, a bias has been introduced in leaving out small crustaceans and sponges. Although not important in terms of biomass the sponges would increase the relative importance of filter feeders. Van Driel (1978) has studied the macrofauna associated with *Pyura* on shallow subtidal reefs in this area. He found an average ash-free dry biomass in these areas of about 2,7 kg m^{-2} of which *Pyura* made up 98%. Filter feeders thus increase rapidly in importance in the subtidal. These rocky shores may be seen as interacting with the shallow subtidal mainly in the form of energy removed by motile grazers and carnivores which move up into the intertidal to feed during the high tide.

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