Macrofaunal community structure and zonation of two sandy beaches on the central Namib coast, South West Africa/Namibia

THEODORE E. DONN, JR. and ANDREW C. COCKCROFT

Department of Zoology, Institute for Coastal Research, University of Port Elizabeth, P.O. Box 1600, Port Elizabeth 6000, South Africa

Received July 1988; accepted February 1989

ABSTRACT

Two exposed beaches on the central Namib coast were sampled quantitatively to determine intertidal macrofaunal community structure and zonation. The shallow subtidal macrofaunal community of the more protected beach was sampled using a diver operated suction sampler. Both beaches support moderately rich communities showing affinities to regions both to the north and south. Zonation patterns of the macrofauna on both beaches are discussed and compared with other sites. The bivalve, *Donax serra,* inhabits different zones on the two beaches and the implications of this for the biology of the species is discussed. A clear increase in subtidal species richness and biomass was found with depth. The subtidal macrofaunal zonation pattern is discussed and compared with other studies.

INTRODUCTION

The benthic macrofaunal communities of the central Namib coast (southern Africa) have received little attention compared to more southerly west coast beaches (Bally 1983). Available information comprises a faunal list for Sandwich Harbour (Kensley & Penrith 1977) and benthic surveys of two beaches near Walvis Bay (McLachlan 1985). To the north, Tarr *et al.* (1985) surveyed three beaches on the Skeleton Coast. No subtidal macrofaunal studies have been reported from the Namib coast, although Christie (1976b) surveyed the subtidal macrobenthos of Lamberts Bay on the South African west coast.

Salvat (1964) proposed a zonation scheme for intertidal macrofauna based on water content of the beach. He defined four intertidal zones; a zone of drying reached only by spring high tides, a zone of retention of capillary water, a zone of resurgence subject to much ground water exchange, and a zone of saturation. Bally (1983) has successfully applied this system to beaches on the southwest coast of South Africa. Subsequently, Tarr *et al.* (1985) utilized this zonation scheme in their survey. However, McLachlan (1985) found a tripartite zonation pattern on the beaches he surveyed.

Mclachlan *et al.* (1984), working in the medium to high energy surf zones of the eastern Cape, South Africa, proposed a zonation scheme for subtidal macrofauna. They proposed three zones: (i) an inner turbulent zone which is characterised by highly motile subtidal species which may occasionally appear above the low water mark, (ii) a transition zone, with no 'endemic' species, which marks the area to which the break point might move during storms, and (iii) an outer turbulent zone which is marked by a sudden increase in diversity and biomass as the substratum stabilizes.

In June 1986 the South West Africa/Namibia Directorate of Sea Fisheries commissioned an ecological study of sandy beaches on the central Namib coast. This paper reports on the structure of the intertidal macrofaunal communities of two beaches and the subtidal community of one beach and compares them to previously discussed zonation patterns.

STUDY AREA

The two beaches selected for study were Langstrand (22° 04′ S, 14° 10′ E) and Cape Cross (21° 50′ S, 14° 02′ E) (Figure 1). Langstrand, between Walvis Bay and Swakopmund, is partially protected by Pelican Point to the south. At the time of the study, Langstrand was in a moderate to low energy transverse bar rip state (see Short & Wright 1983 for a description of beach morphology, Knoop *et al.* 1986 for a complete beach description). The Cape Cross study site was located 110 km north of Swakopmund within the Cape Cross Nature Reserve. The site was 6 km north of the nearest access point at Mile 72. The beach had a high berm and was backed by a large pan approximately half a kilometre inland. This beach was in the cresentic bar-beach state (Knoop *et al.* 1986). The beach face was very steep with course grain size . Data on the physical parameters of both beaches are given in Table 1.

METHODS

Two transects on each beach were sampled for intertidal macrofauna. At Langstrand, the first transect (LS-I) was located in the middle of a cusp bay. The second transect (LS-II) was approximately 20 m north of LS-I on the cusp horn. Cape Cross transect one (CC-I) was located in the middle of a relatively uniform stretch of the beach. The second transect (CC-II) was located

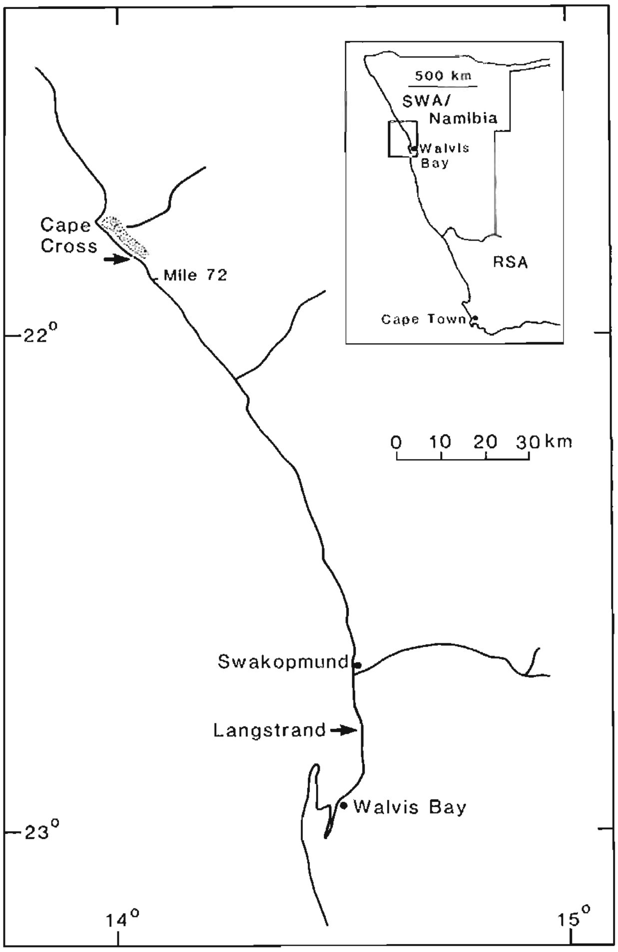

FIGURE 1: Map indicating locations of the two study sites (arrows) on the central Namib coast.

500 m south of CC-I and included a platform near the low water line.

Along each transect, duplicate 0.2 m² quadrats were excavated to a depth of 30 cm at 3 m intervals from 3 m above the high water mark to a water depth of 0.3 m at low tide. The sediment was passed through a 1.5 mm mesh seive and the residue preserved in 5% formalin in seawater. In the laboratory animals were sorted from the sediment, counted and identified to species. Dry mass was determined from sub-samples of preserved specimens.

Data from replicate samples at each 3 m interval were pooled, and the Bray-Curtis similarity measure (Huhta 1979) calculated between levels. The resulting matrix was subjected to cluster analysis by the BMDP 1M computer program (Dixon 1981).

Subtidal macrobenthos was sampled at four depths (2–5 m) off Langstrand using a diver-operated suction sampler, modified as described in McLachlan *et al.* (1984). At each depth triplicate samples of 0.1 m² were taken to a depth of 50 cm, the sand being passed through a 1 mm mesh collecting basket to trap macrofauna.

RESULTS

Data on intertidal community structure of the two beaches are presented in Table 2. The white mussel, *Donax serra,* dominated biomass on both beaches comprizing 83% of the total biomass at Langstrand and 75% at Cape Cross. Numerical dominants shifted between beaches. The mysid *Gastrosaccus namibensis*

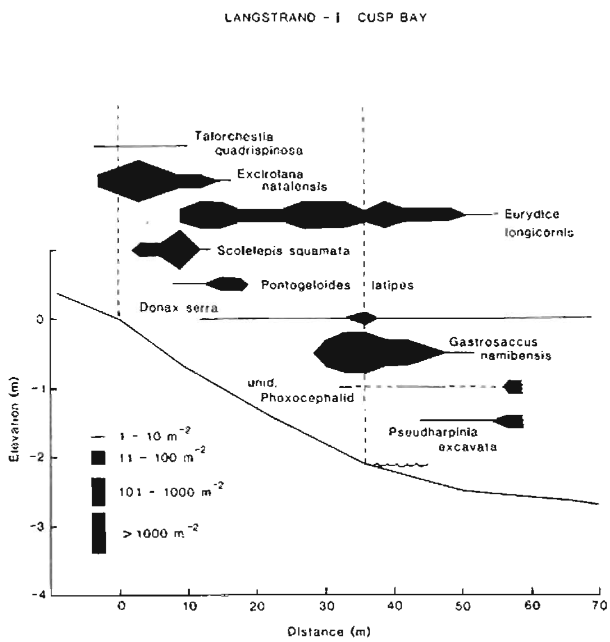

FIGURE 2: Beach profile and species distribution for transect I at Langstrand. Transect was taken down the middle of cusp bay. Dotted lines indicate position of high and low water lines.

TABLE 1: Physical parameters of the study sites. Data from Knoop *et al.* 1986 and McGwynne 1986.

	Langstrand	Cape Cross
Mean grain size (µm)	281	451
	fine – well sorted	course – moderately well sorted
Beach width (m)	35	40
Mean slope	1:18	1:13
Wave height (m)	0.5	3.2
Wave period (s)	15	20
Surf zone width (m)	50	250
Exposure rating (from Mclachlan 1980)	11	12
	exposed	exposed
Beach state	Transverse Bar Rip	Cresentic Bar

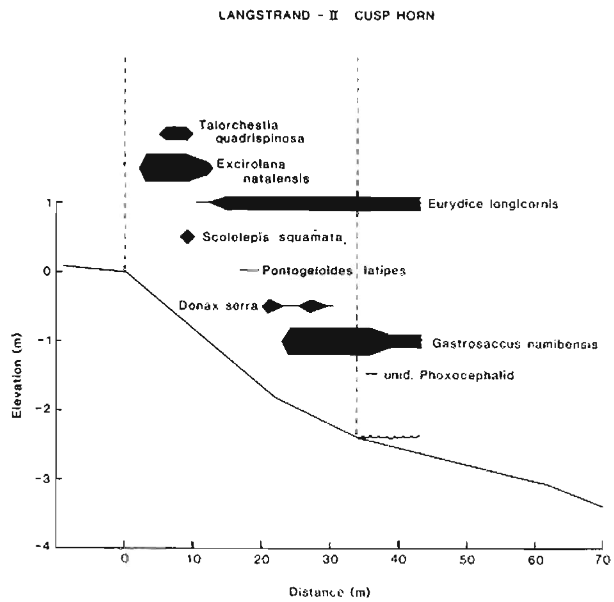

FIGURE 3: Beach profile and species distribution on transect II at Langstrand. Transect taken along cusp horn. Densities given as in Figure 2.

and the isopods *Excirolana natalensis* and *Eurydice longicornis* were dominant at Langstrand. There was a marked difference between the two transects at Langstrand (Figures 2 & 3, Table 2) with respect to population numbers and distribution. In the cusp bay (LS-I) numbers were approximately twice those on the cusp horn (LS-II). Populations were also located lower down the shore on the cusp horn.

At Cape Cross the community was dominated by *Scolelepis squamata*. The phoxocephalid amphipod *Pseudharpinia excavata* was present in high numbers on the platform on transect CC-II. With the exception of this species at Cape Cross, amphipods made up a relatively minor portion of the intertidal macrofauna in terms of both numbers and biomass.

Beach profiles and species distributions for the intertidal transects are presented in Figures 2–5. The isopod *Excirolana natalensis* was found in the upper intertidal while *Eurydice longicornis* was distributed widely throughout the mid and lower intertidal zones. At

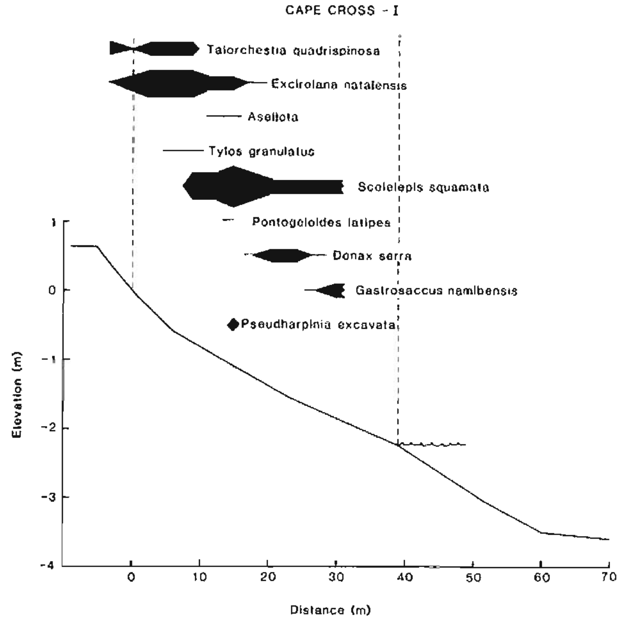

FIGURE 4: Beach profile and species distribution for transect I at Cape Cross. Densities given as in Figure 2.

TABLE 2: Intertidal macrofaunal community structure at Langstrand (LS) and Cape Cross (CC). Values are given as numbers per metre (No.) and grams (dry wt.) per metre (Bio.).

	LS–I		LS–II		CC–I		CC–II	
	No.	Bio.	No.	Bio.	No.	Bio.	No.	Bio.
ISOPODA								
Excirolana natalensis	5 070	49.2	1 980	19.2	2 010	19.5	600	5.8
Eurydice longicornis	4 515	15.0	1 560	5.2	–	–	180	0.6
Pontogeloides latipes	195	6.7	30	1.0	30	1.0	45	1.6
Tylos granulatus	–	–	–	–	45	13.5	45	13.5
Sub. O. Asellata	–	–	–	–	30	0.02	60	0.03
AMPHIPODA								
Talorchestia quadrispinosa	90	0.2	120	0.3	360	0.8	645	1.4
Pseudharpinia excavata	315	0.4	–	–	45	0.1	12 180	14.6
Unidentified Phoxocephalid	240	0.1	30	0.02	–	–	–	–
MYSIDACEA								
Gastrosaccus namibiensis	12 780	20.3	7 290	11.6	150	0.5	150	0.5
POLYCHAETA								
Scolelepis squamata	3 225	17.0	180	1.0	8 250	43.4	9 420	49.5
MOLLUSCA								
Donax serra	240	488.1	210	203.7	240	184.8	420	331.4
TOTALS	26 670	596.8	11 400	241.9	11 160	263.5	23 745	418.9
NUMBER OF SPECIES	9		8		9		10	

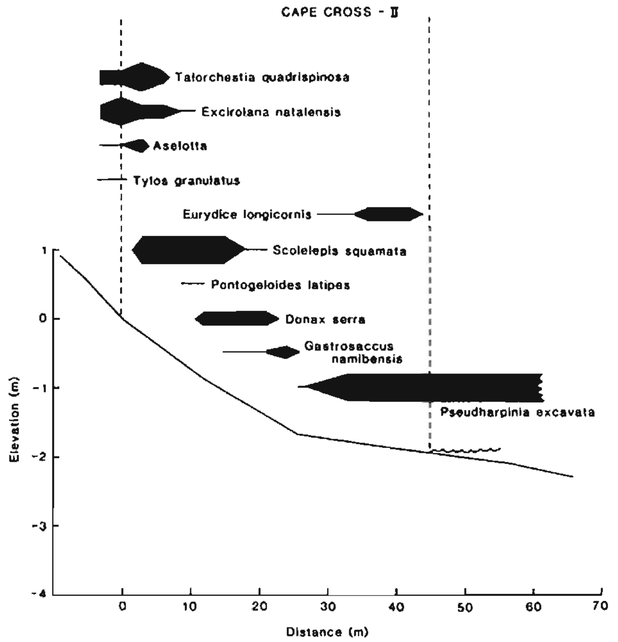

FIGURE 5: Beach profile and species distribution for transect II at Cape Cross. Densities given as in Figure 2.

Langstrand the mysid *Gastrosaccus namibensis* was numerically dominant in the low intertidal and shallow subtidal, whereas the amphipod *Pseudharpinia excavata* occupied the low tide terrace on transect CC-II. *Scolelepis squamata* was abundant on both beaches, occurring in the mid to upper intertidal. The white mussel *Donax serra* exhibited different zonation patterns on the two beaches. At Langstrand it occupied the lower intertidal and extended into the subtidal one. At Cape Cross, however, the population was strictly intertidal.

The distribution of intertidal macrofauna at each site was examined by cluster analysis to determine the zonation pattern. The data from both transects at each site were pooled to construct the dendograms (Figure 6). The two sites yielded slightly different clustering patterns. At Langstrand four clearly defined clusters were present, defining four zones. At cape Cross five less clearly defined clusters were present. Zone II, the zone of retention, at this site appears to be subdivided into two zones.

The density and biomass of the subtidal macrofauna at Langstrand are presented in Table 3. A total of 14 species was recorded: 3 polychaetes, 8 crustaceans, 2 gastropods and one species of nemertean worm. Polychaetes dominated numbers, with *Nephtys hombergi* the most abundant at the 2 m and 3 m stations. The larger *Diopatra n. neopolitana* and *Glycera convoluta* were the most abundant at the 4 m and 5 m stations. respectively. Total dry biomass increased from 0.377 g m^{-2} at 2 m to 18.935 g m^{-2} at 5 m depth.

Polychaetes, again, were the major contributors to total biomass at 2 m and 3m, whereas at 4 m and 5 m gastropods dominated due to the presence of large *Bullia laevissima*.

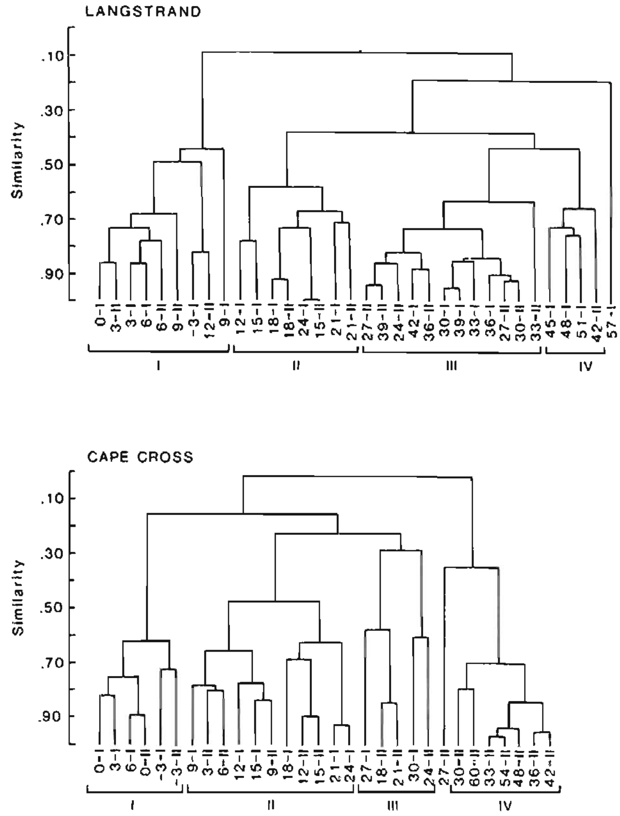

FIGURE 6: Cluster dendograms for intertidal transects at Langstrand and Cape Cross. Zones indicated as follows: I, zone of drying; II, zone of retention; III, zone of resurgence; IV, zone of saturation.

DISCUSSION

The beaches surveyd in this study are located between beaches examined by Bally (1983) on the west coast of South Africa and those examined by Tarr *et al.* (1985) on the Skeleton Coast further north. The intertidal macrofaunal communities in the western Cape Province contain more species than the communities at Langstrand and Cape Cross, but all species present in the latter communities are present on western Cape beaches. The community composition at Langstrand is similar to that reported by McLachlan (1985). However, his estimates of abundance and biomass are considerably lower than those reported here (31% and 11% of the present values, respectively). Comparison with the Skeleton Coast beaches studied by Tarr *et al.* (1985) suggests a shift in community structure towards the north, especially at Bosluisbaai. They suggest that at Bosluisbaai tropical fauna are beginning to replace the temperate fauna found on southern beaches.

The zonation patterns described in this study are similar to those described by Bally (1983) and Tarr *et al.* (1985). In their studies, these authors defined four zones based on Salvat (1964) and then sampled within them. Bally's (1983) analysis allowed him to relate the four intertidal zones to physical factors within the beach and to define indicator species for each. Tarr *et al.* (1985) used this zonation scheme in defining the

TABLE 3: Subtidal macrofaunal community structure at four depths off Langstrand. Densities are given as number per square metre at each depth.

	Individual Dry Mass (mg)	Density (no. m^{-2})			
		Depth (m)			
		2	3	4	5
POLYCHAETA					
Diopatra n. neopolitana	57	–	3	13	10
Glycera convoluta	20	–	3	10	10
Nephtys hombergi	12	13	47	10	5
NEMERTEAN WORMS	30	7	7	17	16
AMPHIPODA					
Urothoe elegans	2	–	7	20	15
Mandibulophoxus stimpsoni	2	–	3	3	5
ISOPODA					
Cirolana hirtipes	15	–	1	1	1
Eurydice longicornis	11	1	–	–	–
Pontogeloides latipes	10	–	–	–	1
MYSIDACEA					
Gastrosaccus namibensis	18	–	–	7	–
DECAPODA					
Diogenes extricatus	1 040	–	–	3	–
Ogyrides saldanhae	40	–	–	3	5
GASTROPODA					
Bullia laevissima	2 170	–	–	5	8
Natica forata	30	–	–	3	–
TOTAL BIOMASS (g m^{-2})		377	1 040	15 938	18 935
NUMBER OF SPECIES		3	7	12	10

zones in which they sampled. Bally (1983) suggested that the indicator species for the zone of retention is the polychaete *Scolelepis squamata.* Also present in this zone are *Eurydice longicornis* and *Pontogeloides latipes.* These latter species are also present in the zone of resurgence. Similarly, Bally (1983) and Tarr *et. al.* (1985) found many species extending throughout both of these zones, making the biotic differentiation of these zones unclear.

In this study four intertidal zones could be distinguished based on species distribution, conforming to Salvat's (1964) four zones. The upper intertidal zone, or zone of drying, was inhabited by the scavenging isopods *Excirolana natalensis* and *Tylos granulatus* and the amphipod *Talorchestia guardrispinosa.* The mid-intertidal was divided into two zones, retention and resurgence. The polychaete *Scolelepis squamata* dominated the zone of retention while the zone of resurgence was characterized by *Gastrosaccus namibensis* and the isopod *Eurydice longicornis.* The low intertidal and shallow subtidal (zone of saturation) was occupied by the mysid *Gastrosaccus namibensis* and two phoxocephalid amphipods. The white mussel *Donax serra* showed a changing zonation pattern, occupying the low intertidal and shallow subtidal at Langstrand and the midintertidal at Cape Cross.

Donax serra is the dominant organism in terms of biomass on the two beaches studied. McLachlan (1985) found *D. serra* on Paaltjies beach but not on Langstrand. The *D. serra* densities reported from these studies are moderate when compared to densities reported from the western Cape (De Villiers 1975; Hutchings *et al.* 1983) and the eastern Cape (McLachlan 1977; Donn 1987).

A comparison of Langstrand versus Cape Cross shows a difference between the zonation pattern of *D. serra* on the two beaches. At Langstrand *D. serra* occupied the low intertidal and shallow subtidal, as it does on Paaltjies beach (McLachlan 1985), while at Cape Cross the population is found in the mid-intertidal. The results from a South West Africa/Namibia Sea Fisheries survey of *D. serra* populations along the coastline indicate that the more northerly populations occur intertidally as compared with the southern populations which are subtidal (P. de Lange, pers. comm.). Such a shift in zonation is also present between western and eastern Cape populations. In the western Cape, *D. serra* is predominantly low intertidal and subtidal (De Villiers 1975). In the warmer waters of the eastern Cape the mussel populations occur intertidally and show a semilunar cycle of migrations (Donn *et al.* 1986). Bally (1983) found that *D. serra* occurred higher on fine sand beaches than on coarse grained beaches in the western Cape. The opposite pattern was observed in this study, possibly due to water flow through the beach from the inland pan. Tarr *et al.* (1985) reported only a subtidal population of *D. serra* at Hoarusib, which is considerably farther north than the Cape Cross site. The factors causing the changes in zonation pattern are unknown, but may include position of the water table, swash patterns or environmental temperature gradients.

At Langstrand the macrofaunal populations in the cusp bay (LS-I) are double those on the adjacent horn (LS-II). McLachlan and Hesp (1984) found that most of the macrofauna on a low energy, cuspate beach in Australia were located within the cusp bays and not on the cusp horns. They proposed two possible explanations for this observation; either there is an active preference for cusp bays with their flatter slopes or the patterns are due to passive sorting by swash movements. In the eastern Cape *Donax serra* has been shown to be more abundance on the flatter portions of the beach (Donn *et al.* 1986). T.H. Wooldridge (pers. comm.) has observed a similar pattern in the east Cape mysid *Gastrosaccus psammodytes*. In these high energy megacusp systems the flatter slopes are on the cusp horns as opposed to the bays. At Langstrand there is no difference between *D. serra* abundance on the horn and in the bay. This may in part be due to the low intertidal position occupied by the population. In the low intertidal, differences in slope are not highly pronounced. In all cases, organisms are more abundant on the regions of the beach with flatter slopes, whether on cusp horns in high energy megacusp systems or in cusp bays in the lower energy reflective systems. These observations support the idea that intertidal macrofauna select the flatter portions of beaches.

Although only four subtidal stations were sampled in this study, an increase in species diversity and biomass with depth was clear. Similar observations have been recorded by Masse (1972), Christie (1976) and McLachlan *et al.* (1984). In light of the zonation scheme for the subtidal macrofauna on high energy coasts proposed by McLachlan *et al.* (1984), the present results indicate that the 2 m and 3 m stations at Langstrand may fall into the transition zone and that the 4 m and 5 m stations may be the start of the outer turbulent zone as indicated by the rapid increase in diversity and biomass. Biomass recorded by McLachlan *et al.* (1984) ranged from 1 to 10 g m^{-2} in the transition zone and 10–150 g m^{-2} in the outer turbulent zone. The biomass recorded in this study (transition zone *ca.* 0.5 g m^{-2} and outer turbulent zone *ca.* 18 g m^{-2}) fall within these recorded ranges. No definite conclusions can be drawn from four sampling stations, but it appears that macrofaunal zonation in the subtidal does occur and can be described by the scheme mentioned above.

In conclusion, the two beaches exhibited moderate to high numbers of individuals and moderate numbers of species as compared to beaches along the southern African coastline (Dye *et al.* 1981; McLachlan *et al.* 1981; Wooldrigde *et al.* 1981; Bally 1987). Community structure is similar to beaches to the north and south. Both intertidal and subtidal species show clear zonation patterns; intertidal species responding to the water content of sediments and swash flow patterns and subtidal species to the effect of wave action. *Donax serra* is anomalous among the intertidal species in that its zonation pattern changes between beaches. It is clear that the responses of species to water movement is the dominant factor affecting their distributions.

ACKNOWLEDGEMENTS

Funding for this project was supplied by the Directorate of Sea Fisheries (South West Africa/Namibia), who also supplied logistical support in the field, and the South African National Committee on Oceanographic Research. We acknowledge the cooperation of the South African Navy (Walvis Bay) who supplied divers and equipment for the subtidal work. We would also like to thank the other members of the Sandy Beach group at U.P.E. for their assistance.

REFERENCES

BALLY, R. 1983. Intertidal zonation on sandy beaches of the west coast of South African. *Cah. Biol. Mar.* 24: 84–103.

BALLY, R. 1987. The ecology of sandy beaches of the Benguela ecosystem. *S. Afr. J. Mar. Sci.* 5: 759–770.

CHRISTIE, N.D. 1976. A numerical analysis of the distribution of a shallow sublittoral sand macrofauna along a transect at Lamberts Bay, South Africa. *Trans. R. S. Afr.* 42: 149–172.

DE VILLIERS, G. 1975. Growth, population dynamics, a mass mortality and arrangement of white sand mussels, *Donax serra* Röding, on beaches in the south-western Cape Province. *S. Afr. Sea Fish. Bd. Invest. Rep.* 109: 1–31.

DIXON, W.J. (ed.). 1981. BMDP Statistical Software. Berkeley, California: University of California Press. pp. 726.

DONN, T.E., JR. 1987. Longshore distribution of *Donax serra* in two log-spiral bays in the eastern Cape, South Africa. *Mar. Ecol. Prog. Ser.* 35: 217–222.

DONN, T.E., JR., CLARKE, D.J., MCLACHLAN, A. & DU TOIT, P. 1986. Distribution and abundance of *Donax serra* Röding (Bivalivia: Donacidae) as related to beach morhpology. I. Semilunar migrations. *J. Exp. Mar. Biol. Ecol.* 102: 121–131.

DYE, A.H. MCLACHLAN A. & WOODRIDGE, T. 1981. The ecology of sandy beaches in Natal *S. Afr. J. Zool.* 16: 200–209.

HUHTA, V. 1979. Evaluation of different similarity indices as measures of succession in arthropod communities of the forest floor after clear-cutting. *Oecologia* 41: 11–23.

HUTCHINGS, L., NELSON, C., HORSTMAN, D.A. & TARR, R. 1983. Interaction between coastal plankton and sand mussels along the Cape coast, South Africa. In: MCLACHLAN, A. & ERASMUS, T. (eds.). Sandy Beaches as Ecosystems. The Hague: Junk Publishers: 481–500.

KENSLEY, B.J. & PENRITH, M.J. 1977. Biological survey of Sandvis. I. Introduction and fauna list. *Madoqua* 10: 181–190.

KNOOP, W., TALBOT, M.M.B. & BATE, G.C. 1986. Morphodynamics of the beaches and surfzones. In: MCLACHLAN, A. (ed.). Ecological Surveys of Sandy Beaches on the Namib Coast. Institute For Coastal Research (University of Port Elizabeth) Report No. 13: 10–18.

MASSE, H. 1972. Quantitative investigations of sand bottom macrofauna along the Mediterranean north coast. *Mar. Biol.* 15: 209–220.

MCGWYNNE, L. 1986. Intertidal interstitial fauna. In: MCLACHLAN, A. (ed.). Ecological Surveys of Sandy Beaches on the Namib Coast. Institute For Coastal Research (University of Port Elizabeth) Report No. 13: 37–52.

MCLACHLAN, A. 1977. Composition, distribution, abundance and biomass of the macrofauna and meiofauna of four sandy beaches. *Zool. Afr.* 12: 279–306.

MCLACHLAN, A. 1980. The definition of sandy beaches in relation to exposure. A simple rating system. *S. Afr. J. Sci.* 76: 137–138.

MCLACHLAN, A. 1985. The ecology of two sandy beaches near Walvis Bay. *Madoqua* 14: 155–163.

MCLACHLAN, A., COCKCROFT, A.C. & MALAN, D.E. 1984. Benthic faunal response to a high energy gradient. *Mar. Ecol. Prog. Ser.* 16: 51–63.

MCLACHLAN, A. & HESP, P. 1984. Faunal response to morphology and water circulation of a sandy beach with cusps. *Mar. Ecol. Prog. Ser.* 19: 133–144.

MCLACHLAN, A., WOOLDRIDGE, T. & DYE, A.H. 1981. The ecology of sandy beaches in southern Africa. *S. Afr. J. Zool.* 16: 219–231.

SALVAT, B. 1964. Les conditions hydrodynamiques interstitielles des sèdiments meubles intertidaux et la rèpartition verticule de la faune endogèe. *C.-r. Acad. Sci., Paris.* 259: 1576–1579.

SHORT, A.D. & WRIGHT, L.D. 1983. Physical variability of sandy beaches. In: MCLACHLAN, A. & ERASMUS, T. (eds.). Sandy Beaches as Ecosystems. The Hague: Junk Publishers: 133–144.

TARR, J.G., GRIFFITHS, C.L. & BALLY, R. 1985. The ecology of three sandy beaches on the Skeleton Coast of South West Africa. *Madoqua* 14: 295–304.

WOOLDRIDGE, T., DYE, A.H. & MCLACHLAN, A. 1981. The ecology of sandy beaches in Transkei. *S. Afr. J. Zool.* 16: 210–218.