Bull. Environ. Contam. Toxicol. 31, 331-338 (1983)

Sandy Beach Molluscs as Possible Bioindicators of Metal Pollution 1. Field Survey

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The ability of many biological species to accumulate pollutants has been used with varying degrees of success to indicate and sometimes quantify metal pollution of the marine environment. The characteristics of monitoring organisms have been described in detail (BUTLER 1971; PORTMANN 1975).

A great variety of molluscs occur around the South African coast, extending as it does from the sub-tropical environment of Natal to the temperate environment of the Cape. The potential of many of these molluscs as bio-indicators has been discussed in general terms on the basis of the reported use of related species (DARRACOTT and WATLING 1975) and certain of these, among them the bivalve *Donax serra* and gastropod *Bullia rhodostoma*, have been included in the national marine pollution monitoring programme (CLOETE and WATLING 1981). However, few data on the accumulator ability of these species or on their tolerance to metals are available.

The aims of this preliminary investigation are 1) to determine the metal concentrations in *D. serra* and *B. rhodostoma* growing along a 500 km stretch of the southern African coast, supplementing data from sediment and water sampling surveys of the same region; and 2) to determine in laboratory studies whether these molluscs accumulate metals, thus meeting some at least of the criteria for monitoring organisms. The field survey data are presented in this paper.

MATERIALS AND METHODS

D. serra and *B. rhodostoma* were collected from sites along the South African coast (Fig. 1) during several surveys in the period August 1978-August 1979. The preparation and analysis of these samples has been described (WATLING and WATLING 1979).

The selection of the most suitable species for this study was not difficult, bearing in mind the criteria for "monitoring organisms" as reviewed by BUTLER (1971) and PORTMANN (1975).

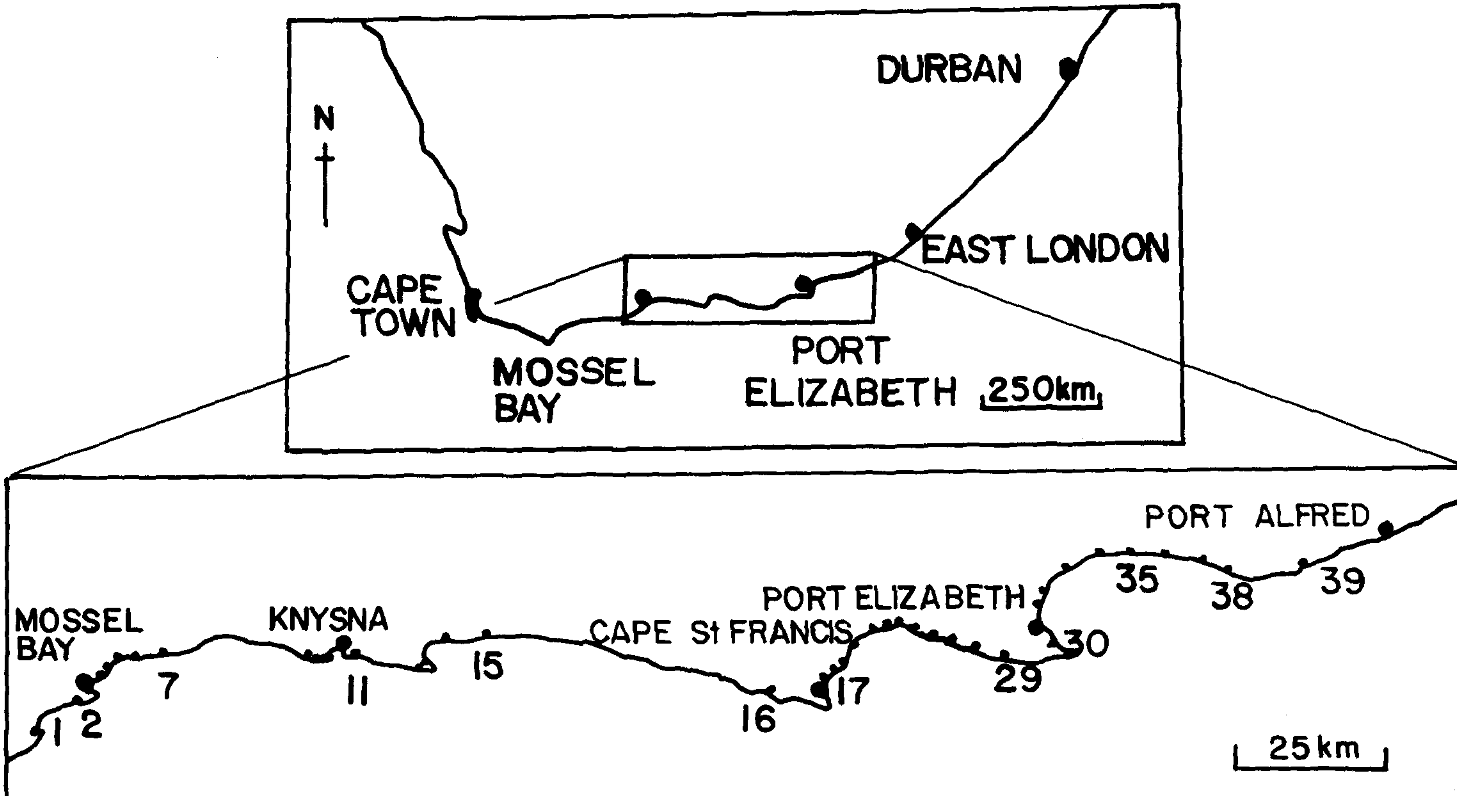

Fig. 1 Study area and locations of sampling sites

Two species of Donax, D. sordidus and D. serra, occur on eastern Cape sandy beaches. D. sordidus is small and undergoes tidal migration. D. serra is the largest species in the genus. The geographical range of D. serra is from Luderitz on the West coast to the Transkei on the East coast of South Africa and its spring tidal position is above the mid-tide level in the eastern Cape. In the eastern Cape region this species does not undergo the normal tidal migration, but exhibits a semi-lunar pattern of movement up and down the intertidal zone (MCLACHLAN et al., 1979b); vast populations occur on some beaches. The reproduction and growth of D. serra (DE VILLIERS 1975 a; b) and the general distribution of D. serra in the eastern Cape, its population, structure, growth, production, aspects of its biology and seasonal changes in the biochemical composition (MCLACHLAN and HANEKOM 1979) have been described.

Bullia are well represented on South African beaches with five intertidal and eight subtidal species, but they do not make ideal monitoring organisms, being both mobile and of a scavenging habit (BROWN 1982b). However, they have a wide geographical distribution and are abundant on many beaches. BROWN (1982a) has reviewed the available data on the biology and physiology of Bullia species. B. rhodostoma is the common intertidal species of the southern and eastern Cape and is the dominant macrofaunal organism on many beaches (MCLACHLAN 1980). It is long-lived, with a slow growth rate, reaching a length of about 40 mm after 10 years (MCLACHLAN et al., 1979a).

The area from which samples were collected is mainly undeveloped and it was expected that the concentrations determined would represent near-background levels for these species. Concentrations in oysters and mussels from this coast indicate that this is an unpolluted area, with the exception of a few isolated places which are almost always associated with urbanization (WATLING and WATLING 1979; 1982). Thus the data from the present survey will serve as a baseline for the future monitoring of the sandy beaches of this region.

RESULTS AND DISCUSSION

Variations in metal concentrations in D. serra and B. rhodostoma are apparent (Tables 1 & 2). These variations are often accounted for by differences in size, the higher levels occurring in smaller individuals. Both zinc and cadmium in B. rhodostoma follow this pattern. In the case of cadmium, the concentrations are slightly higher for a given size of individual in the western part of the survey area, as has also been found for oysters (WATLING and WATLING 1982). The concentrations of cadmium and zinc in B. digitalis have also been surveyed; these data indicate that B. digitalis from the West coast have higher tissue levels of cadmium and zinc than do South coast populations, and that metal concentrations do not increase with increasing

TABLE 1

Metal concentrations in *D. serra* collected from sites on the South African coast

Sample Location (refer Fig.1)	No.		Wet mass (g)	Dry mass (g)	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
					µg metal / g wet tissue								
2 Dana Township	40	$\bar{x}$	8.50	1.45	13.0	0.07	0.82	0.34	81	1.33	0.47	0.19	0.65
(new development)		s			2.3	0.02	0.12	0.05	29	0.64	0.13	0.04	0.29
3 Diaz Beach	4	$\bar{x}$	5.62	0.96	19.3	0.12	1.20	0.06	79	1.39	0.23	0.09	0.82
6 Glentana	3	$\bar{x}$	3.43	0.62	15.6	0.14	1.18	0.03	84	1.15	0.43	0.04	0.26
9 Buffalo Bay	30	$\bar{x}$	8.93	1.99	15.2	0.03	1.14	0.02	128	1.36	0.46	0.06	0.61
		s	1.41	0.28	3.7	0.01	0.15	0.01	26	0.46	0.05	0.01	0.16
14 Keurboomsrivierstrand	10	$\bar{x}$	8.15	1.79	14.3	0.03	1.35	0.01	126	1.58	0.50	0.07	0.45
16 Oyster Bay	28	$\bar{x}$	9.08	1.64	14.6	0.03	1.01	0.02	71	1.73	0.39	0.05	1.26
		s	2.49	0.51	3.6	0.01	0.26	0.01	21	0.90	0.08	0.04	0.51
17 Kromme River mouth	4	$\bar{x}$	8.62	1.77	12.8	0.03	1.00	0.03	229	1.47	0.41	0.04	0.63
19	1	$\bar{x}$	7.50	1.59	15.6	0.06	1.16	0.08	209	2.30	0.36	0.08	0.65
20	5	$\bar{x}$	5.74	1.12	12.9	0.02	0.88	0.08	222	1.99	0.33	0.04	0.59
21	18	$\bar{x}$	10.30	1.97	12.7	0.03	0.92	0.04	235	2.10	0.23	0.05	0.71
		s	4.34	0.90	2.2	0.01	0.15	0.02	69	0.58	0.09	0.02	0.28
23 Gamtoos River mouth	3	$\bar{x}$	4.34	0.81	11.3	0.04	0.82	0.09	230	1.56	0.25	0.09	0.76
24	8	$\bar{x}$	7.73	1.54	15.9	0.02	1.08	0.07	453	3.69	0.32	0.10	1.03
25	14	$\bar{x}$	10.60	2.07	12.6	0.02	0.93	0.04	291	2.34	0.31	0.07	0.65
26	14	$\bar{x}$	10.24	2.04	13.4	0.05	1.07	0.05	264	2.28	0.32	0.06	0.64
27	11	$\bar{x}$	11.34	2.37	14.7	0.04	1.01	0.03	202	1.90	0.34	0.06	0.56
28	21	$\bar{x}$	10.01	2.14	13.9	0.06	1.14	0.03	181	1.60	0.45	0.07	0.68
		s	3.10	0.81	2.8	0.02	0.23	0.02	69	0.59	0.29	0.05	0.24
29 Maitland River mouth	35	$\bar{x}$	8.50	1.73	11.6	0.04	1.02	0.03	199	1.62	0.40	0.06	0.67
		s	3.36	0.79	3.6	0.02	0.23	0.04	102	0.85	0.06	0.02	0.18
37	2	$\bar{x}$	4.36	0.85	10.9	0.05	0.87	0.03	81	1.48	0.28	0.03	0.55

TABLE 2

Metal concentrations in B. rhodostoma collected from sites on the South African coast

Sample Location (refer Fig. 1)	No		Wet mass (g)	Dry mass (g)	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
					µg metal / g wet tissue								
1 Vlees Point	21	$\bar{x}$	1.96	0.47	32.1	3.9	1.36	0.17	84	1.88	0.18	0.14	3.9
		s	0.46	0.12	7.7	1.6	0.40	0.11	38	0.44	0.07	0.08	1.3
2 Dana Township	18	$\bar{x}$	2.02	0.50	36.3	5.1	1.89	0.13	93	1.66	0.20	0.09	2.4
(new development)		s	0.41	0.11	11.3	2.5	0.49	0.06	39	0.53	0.07	0.05	0.8
3 Diaz Beach	18	$\bar{x}$	3.32	0.58	26.0	2.4	0.90	0.11	24	1.24	0.13	0.08	1.9
		s	0.36	0.10	10.4	0.6	0.27	0.10	12	0.87	0.04	0.04	0.5
4 Hartenbos	30	$\bar{x}$	1.54	0.41	50.0	3.6	1.28	0.12	72	1.56	0.22	0.11	1.6
		s	0.81	0.25	21.1	0.9	0.36	0.08	29	0.46	0.15	0.07	0.9
5 Tergniet	15	$\bar{x}$	2.94	0.75	31.3	3.7	1.41	0.06	49	1.33	0.19	0.08	2.8
		s	0.36	0.22	12.1	1.2	0.32	0.03	23	0.17	0.09	0.03	1.2
6 Glentana	30	$\bar{x}$	0.80	0.19	46.6	8.5	2.23	0.26	80	1.78	0.19	0.11	3.7
		s	0.31	0.06	9.5	1.1	0.92	0.07	20	0.28	0.08	0.09	1.1
7 Herolds Bay	18	$\bar{x}$	2.79	0.67	26.5	4.1	1.42	0.11	63	1.31	0.17	0.06	2.5
		s	0.47	0.13	7.3	1.8	0.61	0.16	25	0.24	0.18	0.04	0.9
8 Walker Point	10	$\bar{x}$	1.85	0.40	43.6	5.2	2.17	0.04	27	1.00	0.11	0.04	0.61
		s	0.50	0.18	7.8	1.0	0.43	0.03	16	0.23	0.07	0.02	0.22
9 Buffalo Bay	17	$\bar{x}$	2.95	0.64	41.1	4.5	2.23	0.05	38	1.04	0.11	0.05	0.65
		s	0.42	0.08	6.4	0.9	0.39	0.03	12	0.11	0.09	0.02	0.21
10 Brenton-on-Sea	16	$\bar{x}$	2.47	0.51	38.1	4.3	2.19	0.04	39	1.03	0.11	0.04	0.5
		s	0.31	0.07	10.7	0.4	0.50	0.02	13	0.16	0.05	0.01	0.16
11 Noetzie	18	$\bar{x}$	2.06	0.50	52.5	5.3	4.42	0.05	22	0.82	0.15	0.03	0.81
		s	0.17	0.05	14.5	1.3	1.26	0.03	6	0.20	0.03	0.01	0.10
12 Cape Seal (west)	25	$\bar{x}$	2.09	0.55	51.5	5.4	1.98	0.13	50	1.19	0.32	0.14	3.3
		s	0.67	0.15	20.3	2.4	0.69	0.08	16	0.18	0.13	0.08	1.6

TABLE 2 continued

Sample Location (refer Fig. 1)	No		Wet mass (g)	Dry mass (g)	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
					g metal / g wet tissue								
13 Cape Seal (east)	19	$\bar{x}$	2.92	0.74	44.4	4.2	3.74	0.04	27	1.10	0.23	0.03	0.68
		s	0.60	0.16	15.4	1.2	0.96	0.02	10	0.41	0.29	0.01	0.23
14 Keurboomsrivierstrand	20	$\bar{x}$	2.56	0.44	50.6	8.8	2.36	0.09	55	0.75	0.17	0.08	2.4
		s	0.82	0.15	17.8	2.7	0.77	0.08	18	0.16	0.07	0.05	1.0
15 Nature's Valley	30	$\bar{x}$	2.19	0.49	46.8	7.1	1.67	0.03	29	0.90	0.15	0.03	0.78
		s	0.27	0.07	13.6	6.3	0.47	0.02	8	0.12	0.10	0.02	0.29
16 Oyster Bay	40	$\bar{x}$	2.32	0.48	37.5	7.2	1.34	0.08	47	0.85	0.11	0.03	2.1
		s	0.47	0.10	11.8	2.4	0.41	0.03	21	0.13	0.06	0.02	0.6
17 Kromme River mouth	20	$\bar{x}$	2.34	0.48	32.1	4.0	1.58	0.11	42	1.49	0.15	0.08	3.6
		s	0.60	0.13	12.6	2.2	0.63	0.12	19	0.21	0.09	0.04	1.1
18	25	$\bar{x}$	2.31	0.50	34.2	3.4	1.05	0.06	24	1.16	0.17	0.04	0.70
		s	0.44	0.13	7.2	0.9	0.41	0.03	5	0.13	0.08	0.02	0.21
19	14	$\bar{x}$	1.72	0.32	37.2	6.8	1.23	0.18	47	1.60	0.13	0.19	2.8
		s	0.47	0.09	13.8	2.0	0.50	0.08	16	0.26	0.08	0.10	1.1
20 Jeffreys Bay	17	$\bar{x}$	2.08	0.55	57.4	3.7	1.72	0.09	33	1.36	0.25	0.08	1.6
		s	0.54	0.16	22.7	1.5	0.47	0.04	11	0.19	0.17	0.04	0.7
21	25	$\bar{x}$	2.30	0.47	31.4	2.6	1.73	0.09	31	1.37	0.22	0.05	0.87
		s	0.53	0.14	11.7	0.9	0.66	0.04	10	0.16	0.12	0.03	0.25
22	8	$\bar{x}$	1.77	0.43	49.6	5.0	2.05	0.14	50	1.58	0.14	0.12	2.9
		s	0.69	0.19	11.0	1.5	0.99	0.05	38	0.41	0.13	0.07	0.9
23 Gamtoos River mouth	15	$\bar{x}$	1.80	0.37	53.3	4.2	2.20	0.06	29	1.40	0.18	0.07	1.25
		s	0.6	0.15	10.2	1.1	0.77	0.02	8	0.32	0.06	0.05	0.49
24	25	$\bar{x}$	1.82	0.37	50.6	5.3	2.10	0.13	38	1.82	0.10	0.08	3.6
		s	0.62	0.17	23.8	3.1	1.09	0.05	19	0.72	0.06	0.05	2.6
25	15	$\bar{x}$	2.01	0.38	37.7	3.1	1.40	0.08	33	1.11	0.19	0.06	1.22
		s	0.63	0.16	15.6	1.3	0.61	0 06	13	0.35	0.07	0.04	0.41
26	14	$\bar{x}$	1.58	0.29	37.2	3.7	1.35	0 11	35	1.21	0.33	0.08	1.29
		s	0.92	0.23	14.7	1.0	0.29	0 05	10	0.20	0.14	0.04	0.53

TABLE 2 continued

Sample Location (refer Fig. 1)	No		Wet mass (g)	Dry mass (g)	Zn	Cd	Cu	Pb	Fe	Mn	Ni	Co	Cr
					µg metal / g wet tissue								
27	30	$\bar{x}$	1.93	0.40	44.4	4.8	1.44	0.09	49	1.33	0.22	0.05	1.5
		s	0.71	0.14	15.2	1.5	0.48	0.05	22	0.31	0.16	0.03	0.6
28	35	$\bar{x}$	1.78	0.39	28.6	5.1	1.44	0.06	37	1.17	0.19	0.07	0.87
		s	0.96	0.24	7.7	1.8	0.37	0.03	10	0.33	0.09	0.04	0.33
29 Maitland River mouth (1978)	20	$\bar{x}$	2.72	0.57	36.4	4.3	1.51	0.07	38	1.15	0.20	0.12	0.81
		s	0.82	0.21	11.9	0.9	0.32	0.04	26	0.16	0.16	0.05	0.28
(1979)	28	$\bar{x}$	2.56	0.68	21.4	2.8	1.07	0.08	27	1.67	0.12	0.04	1.6
		s	1.32	0.32	8.3	0.7	0.68	0.06	7	0.45	0.13	0.01	0.9
30 Kings Beach	15	$\bar{x}$	0.90	0.17	43.1	3.7	2.01	0.11	54	1.65	0.17	0.11	1.84
		s	0.21	0.06	13.0	0.8	0.31	0.04	17	0.48	0.09	0.06	0.72
31 Fishwater Flats	12	$\bar{x}$	1.44	0.30	30.6	4.7	2.06	0.09	45	1.26	0.22	0.14	0.81
		s	0.24	0.06	2.9	0.9	0.26	0.03	13	0.07	0.18	0.09	0.16
32 Hougham Park	8	$\bar{x}$	1.70	0.36	35.5	3.6	1.89	0.14	38	1.52	0.15	0.10	1.33
		s	0.85	1.20	11.8	0.7	0.32	0.04	22	0.30	0.06	0.05	0.72
33	13	$\bar{x}$	2.15	0.38	42.3	2.1	1.74	0.09	52	1.67	0.15	0.12	2.4
		s	1.04	0.20	12.7	0.6	0.55	0.03	15	0.52	0.05	0.07	0.4
34	16	$\bar{x}$	0.86	0.15	44.7	2.3	1.48	0.27	51	1.37	0.20	0.13	2.6
		s	0.19	0.04	9.0	0.5	0.37	0.22	18	0.23	0.08	0.10	0.6
35	34	$\bar{x}$	1.17	0.28	47.6	3.5	1.53	0.06	40	1.61	0.10	0.06	1.8
		s	0.34	0.08	14.3	1.0	0.26	0.04	6	0.16	0.05	0.03	0.5
36	15	$\bar{x}$	0.85	0.20	47.1	3.0	1.94	0.29	64	1.71	0.22	0.16	4.1
		s	0.20	0.05	15.3	0.8	0.47	0.06	23	0.30	0.09	0.12	1.5
37 5 km west of Woody Cape	20	$\bar{x}$	2.51	0.53	47.5	3.3	1.94	0.11	44	1.55	0.17	0.08	1.9
		s	0.55	0.13	8.3	2.9	2.18	0.03	14	0.29	0.07	0.03	0.4
38 Woody Cape	25	$\bar{x}$	1.25	0.25	59.6	4.1	1.46	0.12	46	1.36	0.11	0.05	1.8
		s	0.32	0.07	16.8	1.4	0.29	0.04	14	0.22	0.07	0.03	0.4
39 Cannon Rocks	3	$\bar{x}$	0.89	0.20	58.3	3.7	1.51	0.11	38	1.28	0.11	0.04	1.7

size of individuals (K.C. DAVIES, Unpublished data). These findings tend to support those of the present survey. The results of a 12-month study to measure seasonal variations in metal concentrations were inconclusive, but indicated that differences due to size were dominant and masked any seasonal variations.

In summary, biologically, D. serra and B. rhodostoma fulfil many but not all the criteria for monitoring organisms. Practically, both species are of an adequate size for analysis; larger individuals should be collected so as to minimise concentration differences due to size. D. serra is often less abundant and more difficult to locate, but B. rhodostoma is more mobile and may, in fact, migrate out of a polluted area. Nevertheless, both may make a useful contribution to the coastal monitoring programme as a whole.

Acknowledgements. The research was carried out as part of the National Programme for Environmental Sciences (Marine Pollution Section) and the financial assistance of the Department of Environment Affairs is gratefully acknowledged.

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Accepted March 23, 1983