Human recreational activity and its impact on a metropolitan coastline.

By

L. van Herwerden

Thesis submitted in fulfillment of the requirements for the degree of Master of Science in the Department of Zoology, University of Cape Town, under the supervision of Prof. C.L. Griffiths.

September 1989

" And it is a strange thing that most of the feeling that we call religious, most of the mystical outcrying which is one of the most prized and used and desired reactions of our species, is really the understanding and attempt to say that man is related to the whole thing, related inextricably to all reality known and unknowable ... It is advisable to look from the tide pool to the stars and then back to the tide pool again. "

John Steinbeck

'The log from the Sea of Cortez'

Dedication

To my parents, Carl and Calyn - my daughter

Declaration:

Throughout this study I was involved in the gathering, capturing, assimilation and interpretation of data used in all the chapters of this dissertation, as well as the writing up of the work (including any coauthored papers).

Many others were involved in the accumulation of data for specific chapters, or the application of their expertise in the interpretation of analyzed data - they are acknowledged at the end of the relevant chapters.

Abstract:

Recreation has an important social function in modern societies, with ever-increasing pressures in the day-to-day life being felt by most people. This study addresses the impact of recreational activity on metropolitan shorelines, with particular reference to the False Bay shoreline. During summer holiday periods shoreline utilization in the Western Cape peaks on the public holidays of 26 December, 1 and 2 January, beach attendances reaching levels of 2 to 10 times higher than attendances on other days during the summer holidays. The greatest proportion of visitors to the beach (94%) engage in non-exploitative activities, such as sunbathing and swimming. Most visitors occur on the beaches between 12h00 and 16h00, week-ends being most popular during out-of-season periods, but in-season week day attendances exceed those of week-ends. Only 6% of visitors surveyed were engaged in exploitative activities such as angling and bait- or food-gathering. Conservation awareness of visitors to the shore is related to the place of residence of the person, as well as activity engaged in by the person.

Fish numbers and their size frequency distributions in protected areas differs to those of unprotected areas. If boulders on a sheltered shore are over-turned during bait gathering it has an adverse effect on the boulder communities, whether the boulders are replaced or left over-turned. When bait gatherers target on mussel- worms as bait, they may cause inadvertent damage to the primary matrix of mussel bed or tube- worm reef in the process, thereby affecting ecological succession processes in the intertidal environment. Management of metropolitan shorelines must therefore provide for quality recreational experiences,

while applying conservation measures to selected areas that are susceptible to over-exploitation under the onslaught of ever-increasing numbers of recreationists. For such measures to be of any benefit to the marine environment, it is essential that people are not only informed, but that the regulations are also properly enforced.

Contents:

Chapter 1

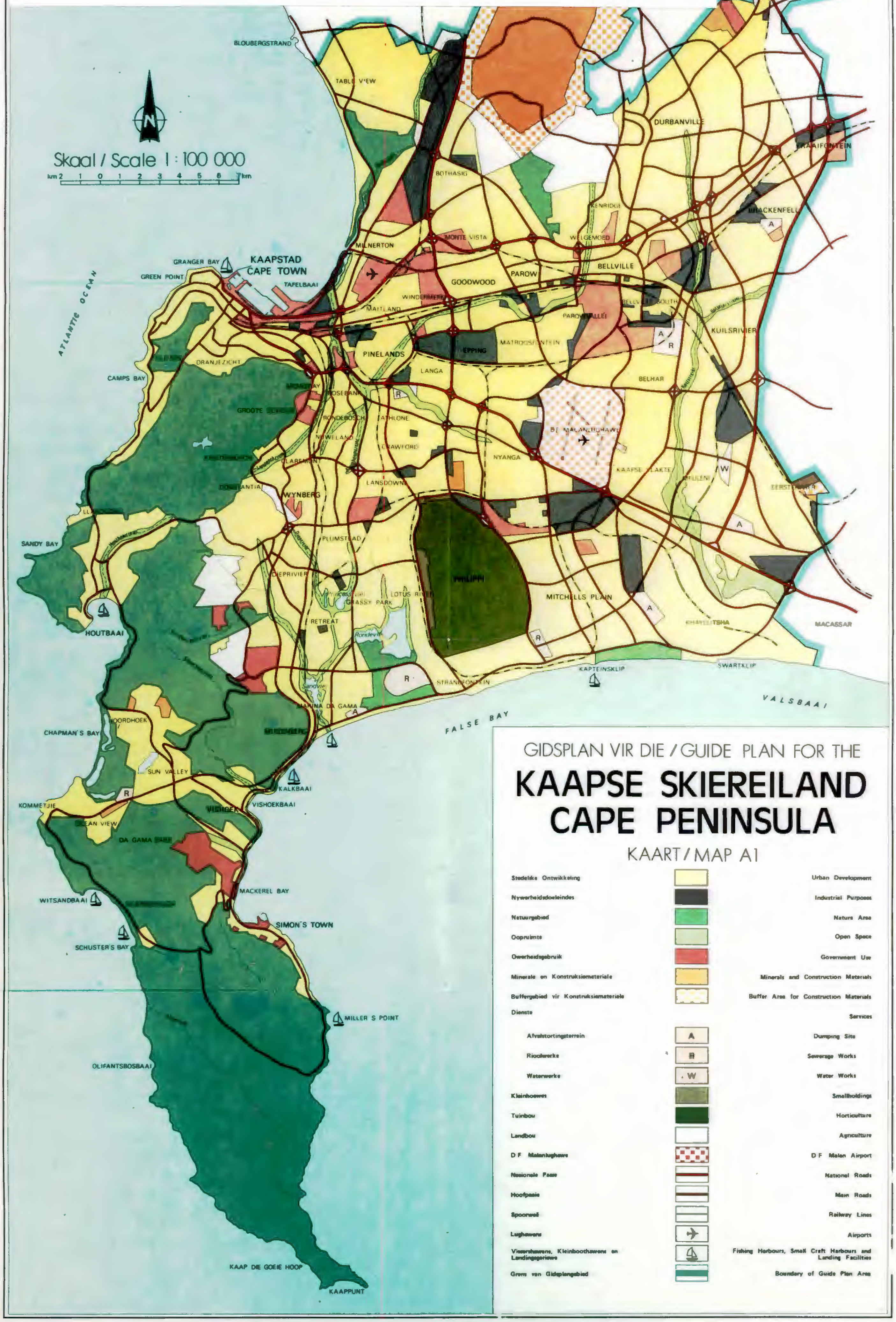
Introduction

Introduction:

Recreation can be defined as "any experience voluntarily engaged in largely during leisure ... from which the individual derives satisfaction" (Ditton & Stephens 1976, in Heath 1987). In developed countries recreation forms an integral part of the 20th century lifestyle. Opportunities for recreation outside of the urban environment have increased with the expansion of public transport networks and of private transport. Jubenville (1976) (in Heath 1987) has estimated that recreation in wilderness areas will increase by 800% from 1976 to the year 2000. Recreational facilities of the coast and nearshore waters are in demand, both in the short- and long-term, considering that 50 - 70 % of the world population is resident along coastlines (Ray 1984, in Hockey 1989). The coastal zone landscape diversity, aesthetic attributes and its potential for leisure and recreational activities is an exceptional attraction to most people. There is obviously an increasing need for management of these coastal resources, as escalating recreation is positively correlated with development, pollution and exploitation pressures, all of which tend to destroy the very attributes recreational users seek. A primary goal of coastal zone management should be to increase public access to the shoreline for recreation purposes, while preserving the natural state of this resource (Vogt 1979, in van der Merwe 1988), as recreation plays such an important role in society.

The South African tourist industry and therefore recreation demand is expected to increase considerably, which means that recreational activities and their impact will intensify in the

Figure 1.1: Map of the greater Cape Town Metropolitan area, as projected to 2010 (Source: Guide Plan)



Melkbosstrand
Robbeneiland
Bloubergstrand
Table View
Milnerton
CAPE TOWN
KAAPSTAD
Sea Point
Green Point
Mouille Point
Camps Bay
Llandudno
Houtbaai
Duikerpunt
Chapman's Point
Noordhoek
Kommetjie
Slangkoppunt
Sun Valley
VISHOEK
Ocean View
Da Gama Park
Scarborough
Muizenberg
St. James
Kalkbaai
SIMON'S TOWN
SIMONSTAD
Rocklands
Miller's Point
Partridge Point
Cape of Good Hope
Nature Reserve
Smitswinkelvlakte
The Cauldron
Kaappunt
Kaap die Goeie Hoop
Durbanville
Kraaifontein
BELLVILLE
Parow
Goodwood
Maitland
Epping
Pinelands
Athlone
Rondebosch
Claremont
Kenilworth
Wynberg
Plumstead
Retreat
Grassy Park
Matroosfontein
Bellville South
Kuilsrivier
Blue Downs
Lansdowne
Nyanga
D. F. Malan
Mfuleni
MITCHELLS PLAIN
Strandfontein
Macassar
Eersterivier
STELLENBOSCH
PAARL
SOMERSET WEST
STRAND
Gordon's Bay
Harmonie strand
Sir Lowry's Pass
Rooiels
Pringle Bay
Betty's Bay
Kaap Hangklip
Seal Island
FALSE BAY
VALSBAAI

broad sandy basin encompassed by these high relief areas. The mountains have thus remained unspoilt, as they are unsuitable for property development and as such provide great scope for conservation, recreation and tourism. The low lying regions must then support the bulk of the population, due to the suitability of the terrain for development (Malan 1982). The False Bay shoreline, forming the southern boundary, is varied in form, having large tracts of sandy beaches adjoining the Cape Flats to the north with steep rocky fringes and cliffs along the mountainous east and west banks , so that the provision of natural facilities for shoreline activities is exceptionally diverse. False Bay also has moderately warm water (12 - 21 ^{o}C, Maritime Weather Office, Silvermine), which makes it more popular for watersports, such as swimming, relative to the cold, upwelled waters of the West Coast (10 - 16 ^{o}C, ESKOM Weather Reports).

In summer the predominant South Easterly wind brings nutrient rich, upwelled water into False Bay; this attracts huge shoals of pelagic fish, which are then preyed upon both by game fish and by man. Pelagic species include: Snoek (Thyrsites atun), horse mackerel (Trachurus trachurus), Sardine (Sardinops ocellata), Yellowtail (Seriola pappei) and Tuna (Thunnus thynnus and T. albacares). Although purse-seine netting and bottom trawling is no longer allowed in False Bay, seine netting and commercial line fishing of these stocks is extensive. The Bay also has stocks of resident fish that form the basis for commercial and recreational line fishermen. Resident fish include: Kabeljou (Johnius hololepidotus), Steenbras (Petrus rupestris, Lithognathus lithognathus and L. mormyrus), Galjoen (Coracinus capensis), Red Roman (Chrysoblephus laticeps), Silverfish (Argyrosona argyrozona) and Hottentot (Pachymetopon blochii, P. grande and P.

aeneum). Resident seabird and seal populations are also in abundance, while dolphins, killer whales and Southern Right whales are frequent visitors. A Jackass penguin colony recently established itself at Boulders on the eastern shore of the Bay and is fully protected. Branch and McQuaid (Branch, 1980) undertook a survey of the species diversity on various rocky shores along the Peninsula coastline and found species richness of between 90 and 137 for sites in False Bay, which reflects the richness of the intertidal communities on this coast.

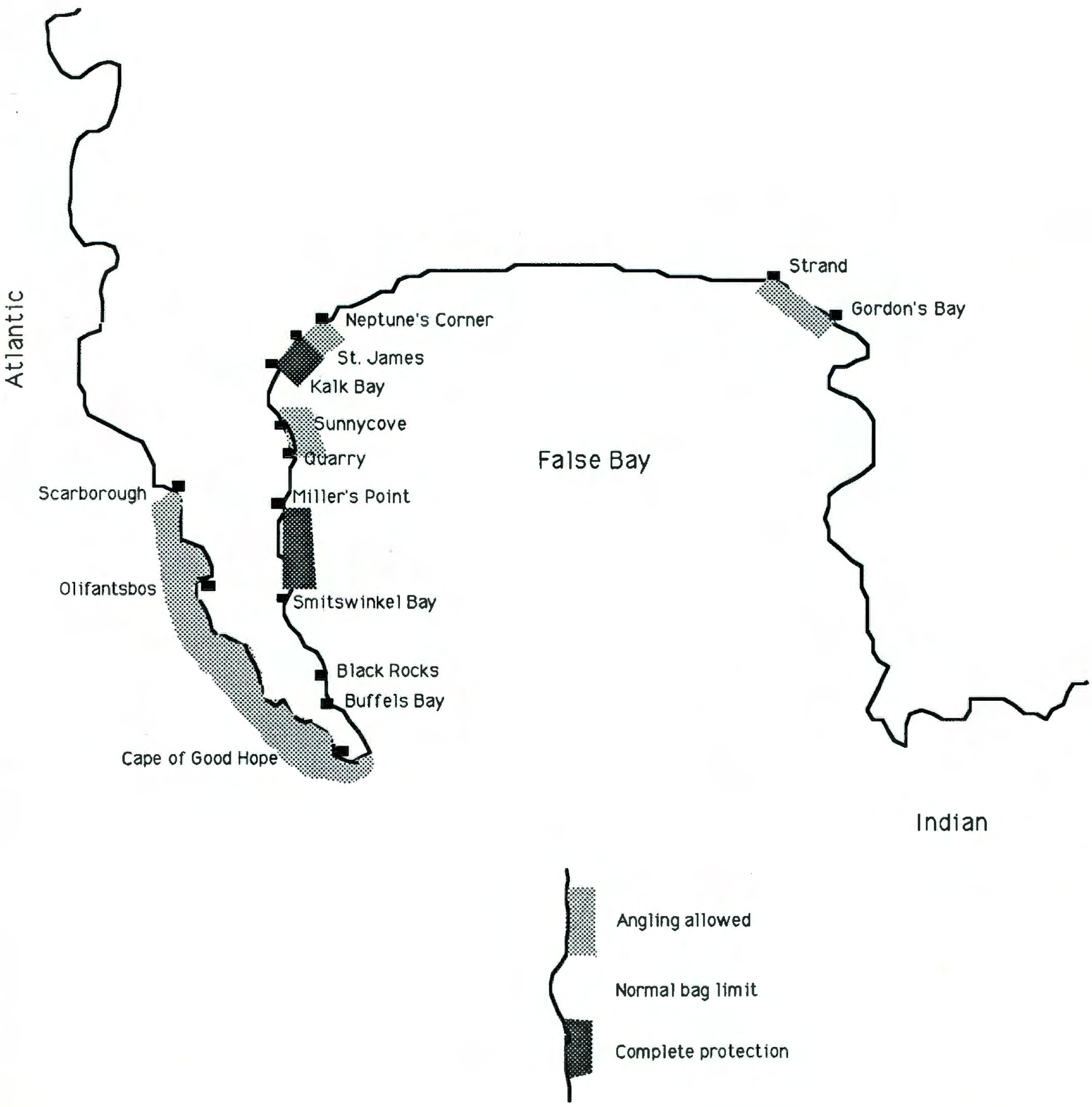
False Bay means different things to different people: to the tourist it is the integrated marine and coastal environment, characterised by the vast expanse of water, impressive mountain ranges and natural beauty. Gussow (1976) (in Blomberg 1982) made this important observation: "any consideration of visual quality and the coastal zone must deal with biological and emotional hungers, for the visual environment is not merely a passive backdrop to human activity, it is the stage on which we move."

Siegfried and Davies (1982) noted that conservation is for and about people, if there were no people there would be no need for conservation! In this light it is important to note that only 2% of the land surface and .001% of the waters of this planet are included in protected areas (Siegfried & Davies 1982). There are increasing demands on these few reserves for a variety of human requirements, of which recreation is an important component, while unallocated natural areas and their resources diminish under the pressures of expanding agriculture, grazing, fishing, industrial and urban development, as well as increasing human populations.

In recent years parts of False Bay have been afforded some conservation status (Fig. 1.3) : In 1979 the Castle Rocks marine sanctuary was established, stretching from a beacon at Miller's Point (Bakoven Rock) to a second beacon at Smitswinkel Bay (Baboon Rock), from the highwater mark 1 nautical mile seaward, however it lost its status as a sanctuary when it was declared open to commercial line fishing of Snoek in November 1988. In February 1986 some experimental conservation areas were declared: Neptune's Corner to St. James tidal pool and the southern end of Fish Hoek to Glencairn tidal pool were given conservation status from the highwater mark 500m seaward, however, fishing by rod and reel and the collection of washed up bait is still permitted in these areas. St. James tidal pool to Kalk Bay harbour wall was given complete conservation status, ie. no collection of any marine organism, from the highwater mark 500m seaward, is permitted in this area. A further marine reserve was declared in February 1987 - Gordon's Bay harbour wall to the Louren's River mouth, where only fishing by rod and reel and the collection of washed up bait is permitted from the highwater mark 500m seaward. The remainder of the False Bay coastline is subject only to the general regulations, which stipulate size and bag limits of target species (Table 3.1).

It is the objective of this dissertation to identify some of the patterns and intensities of shoreline recreation with particular emphasis to the highly utilized False Bay coastline, as an example of a metropolitan seashore. The emphasis is on recreational activities and therefore some exploitative activities that are pursued as recreational activities are considered, but large scale exploitation and the impact of commercial activities is beyond the scope of this study.

Figure 1.3: Map of the conservation areas along the False Bay shoreline



At the outset the study quantifies intensities of shoreline utilization along most of the Peninsula shoreline, thus identifying areas of maximum recreational pressure (Chapter 2). This places the subsequent section, which addresses patterns of shoreline utilization along a section of the False Bay coastline, into perspective within the subregion (Chapter 3). An assessment of the public awareness and attitude towards marine conservation along the False Bay shores is then presented, having previously established recreational patterns and activities (Chapter 4). The next section presents preliminary findings of an evaluation of reef fish assemblages within the Castle Rocks marine reserve and adjacent areas, which are still subject to both recreational and commercial fishing activities (Chapter 5). Specific activities that are (potentially) exploitative are then singled out: the impact of boulder disturbance, which occurs when inquisitive shore-users or collectors over-turn boulders in search of organisms, is discussed in the next section (Chapter 6). This is followed by another specific examination of the potential impact on the mussel-beds that the exploitative activity of gathering mussel-worms (Pseudonereis variegata), which are used as bait by some rock anglers (Chapter 7). Finally, a literature review is presented, providing a general discussion of human recreational activities and their impact on the False Bay coastline and metropolitan coastlines world-wide (Chapter 8). This section concludes with a consideration of management implications relevant to an urban shoreline in general and for the False Bay coastline in particular.

Chapter 2

Shoreline utilization in a rapidly growing, coastal metropolitan area: the Cape Peninsula, South Africa

(Published in Journal of Ocean and Shoreline Management 12 (2) 169 - 178)

Ocean & Shoreline Management **12** (1989) 169–178

Shoreline Utilization in a Rapidly Growing Coastal Metropolitan Area: The Cape Peninsula, South Africa

L. van Herwerden & R. Bally

Marine Biology Research Institute, University of Cape Town, Private Bag, Rondebosch, 7700, Republic of South Africa

(Received 12 September 1988; accepted 13 November 1988)

ABSTRACT

An aerial survey of the Cape Peninsula, South Africa, shoreline (34° S, 18°W) was undertaken to determine patterns and intensities of non-exploitative shore utilization during peak summer holiday periods (mid-December–mid-January). Data was gathered by aerial survey on six occasions during the period December 1985 to January 1988. It was found that beach attendances on traditional peak days (public holidays on 26 December, 1 January and 2 January) were 2–10 times higher than attendances on other days within the peak holiday season. Management plans must therefore take cognizance of extreme peaking of beach utilization on a few specific days of the year.

INTRODUCTION

Approximately seventy percent of the world population is resident along coastlines.[1] Hence, there is a high utilization pressure on coastal recreational facilities and environments. Management of coastal areas for both recreation and conservation purposes must be designed to cope with periods of maximum recreational pressure, as it is at these times that sites deteriorate due to over-utilization, decreasing the potential of the area for recreation and conservation.[2]

The current South African population of 25 million is projected to double within the next 30 years.[3] More specifically, the Cape Metropolitan Area population is expected to increase 2·1 times from 1·7 million

Ocean & Shoreline Management 0951-8312/89/$03·50

to 3·6 million during the period 1980–2000.[4] As demands on recreational facilities are primarily a function of the residential population of an area, and to a lesser extent of the influx of visitors during peak holiday seasons, a long-term problem exists of an ever-increasing metropolitan population that will exert an escalating pressure on limited coastal resources. The Western Cape (Fig. 1) receives over 800 thousand visitors annually, over half of which arrive during the peak holiday season (December to mid-January) and most of the remainder

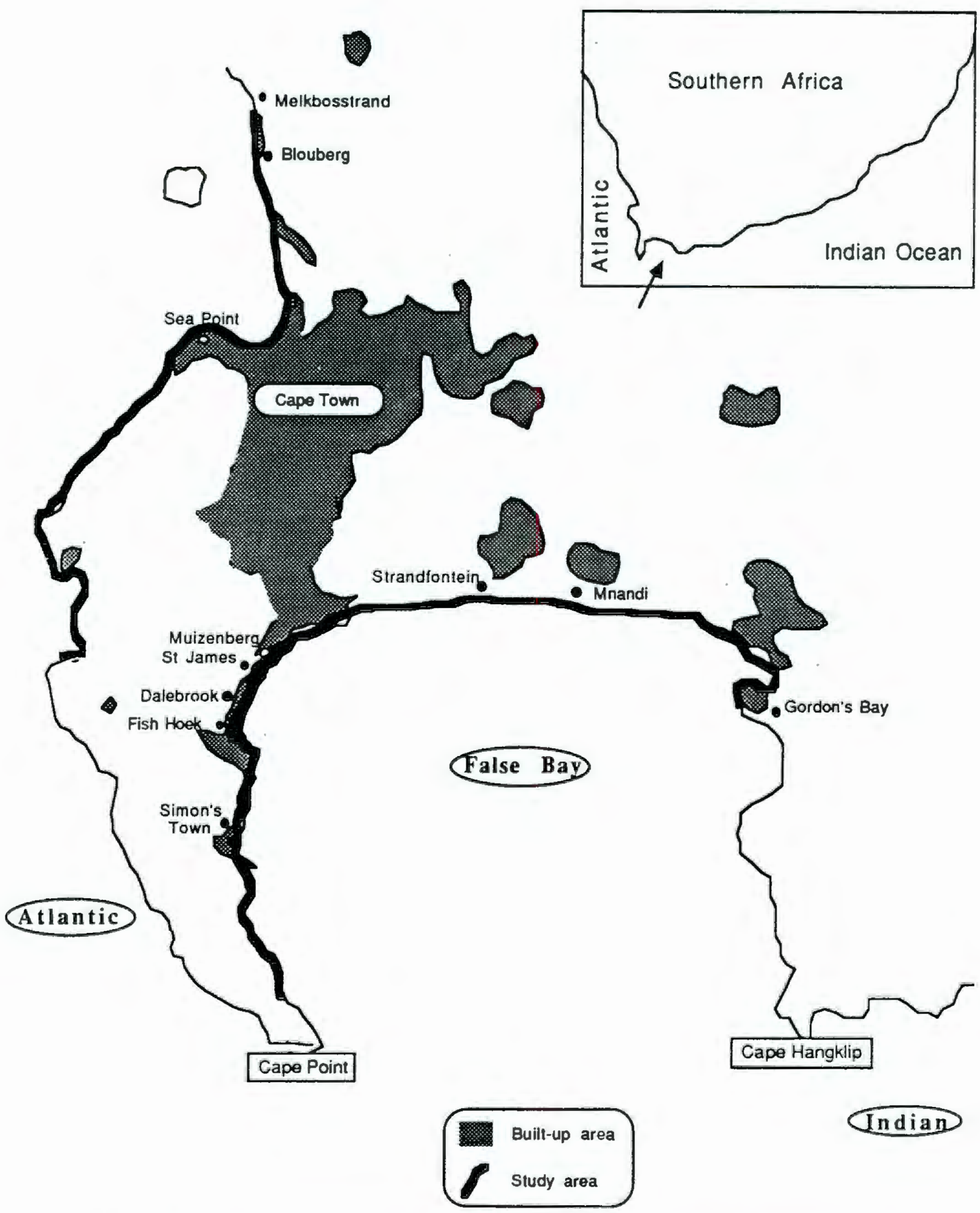


Fig. 1. Map showing study area in relation to South African coastline.

arrive during the second peak (mid-January to the end of April) (Captour, pers. comm.). Furthermore, as socioeconomic patterns change in South Africa, living standards will improve, mobility and leisure time will increase for a large proportion of the South African population, and the demand for recreational facilities will grow at a rate exceeding that of the population growth alone.

The coastal zone is a traditionally favoured recreational and holiday site, but it is also ecologically sensitive. It thus has a maximum carrying-capacity[5,6] and will therefore not be able to accommodate an indefinite expansion of recreational facilities.

This study was conducted to examine coastal utilization patterns along the Cape Peninsula coast, with a view to predicting future pressures and impacts, so that future management of the area can be based on these predicted requirements.

METHODS

Aerial surveys were conducted once a day on specific days within the peak holiday period between 1985 and 1988. A light aircraft was used, flying at approximately 350 m altitude along the 141 km stretch of coastline from Gordon's Bay to Blouberg (Fig. 1). Oblique colour transparencies of areas with concentrations of people were taken using a 35 mm single lens reflex camera fitted with a 50–110 mm lens. The photographs were screened and total counts were made of the numbers of people at each of the sites surveyed. Flights were only undertaken during peak holiday seasons and when beach attendances were expected to be high due to favourable weather conditions (Table 1). Flights were carried out between 10.00 and 16.00 h, when beach attendances along the peninsula coast were expected to be at their maximum.[7,8]

The counts obtained from the photographs represent only non-exploitative activities, which include sunbathing, walking, swimming, surfing, boardsailing and paddleskiing. The patterns of utilization by 'exploiters' (fishermen, bait collectors and snorkel divers) are not included in the scope of this survey for two reasons: firstly, most exploitation activities occur on rocky shores, and due to the lack of visual contrast it is difficult to assess numbers accurately from aerial photographs. Secondly, exploitative activities do not necessarily coincide with good weather, but rather follow the tidal patterns (bait gathering at low tide, angling at turning tides). A further group of coastal exploiters—boat-anglers, snorkel divers, crayfishers, abalone

TABLE 1
Weather Data for Days on which Aerial Surveys Were Carried Out

Weather conditions	*Date*					
	Jan. 2 1985	*Jan. 1 1986*	*Dec. 26 1986*	*Dec. 19 1987*	*Jan. 1 1988*	*Jan. 10 1988*
Time of low tide	05.56	12.38	04.32	07.57	07.46	13.03
Time of high tide	12.09	18.38	10.53	14.05	13.45	18.59
Wind speed, knots, at 14.00 h	10	20	10	10	10	10
Wind direction, at 14.00 h	NW	S	SE	S	S	SW
Cloud cover, octans, at 14.00 h	4/8	0/8	1/8	1/8	6/8	0/8
Minimum air temperature, °C	15·3	17·0	14·4	12·6	16·4	13·8
Maximum air temperature °C	28·2	26·0	23·1	25·3	24·9	29·7

Source: Weather Bureau, D. F. Malan Airport, Cape Town.

fishers and spearfishers—are out of range or difficult to spot using aerial surveys.

RESULTS AND DISCUSSION

The study sites

The Cape Peninsula is a largely rocky, mountainous feature dominated by the Table Mountain chain, connected to the mainland by a low-lying sandy plain known as the Cape Flats. Historically, urban development has centred on the slopes of Table Mountain, initially starting around the safe anchorage of Table Bay, and then gradually spreading southwards, mainly along the eastern sides of the Table Mountain chain. Urbanization of the Cape Flats is a recent development, and is proceeding at an ever-increasing rate, although the provision of housing still lags well behind demand.

The shoreline in the study area is thus dominated by rocky shores along the mountainous section of the Peninsula, interspersed with pocket beaches of sand or mixed sand and rock.[9] The shoreline along the low-lying Cape Flats consists of long sandy beaches, interrupted by occasional rocky outcrops or headlands. Table 2 shows the size distribution of the coastal recreational areas discussed in this study; over 70% are less than 2 km in length, reflecting the rugged shoreline topography of the Cape Peninsula.

TABLE 2

Mean Numbers and Densities of People Visiting Specific Parts of the Study Area between 13.00 and 15.00 h on Surveyed Days

Site	*Shore type*	*Facilities*[b]	*Length of beach (km)*	*Mean number (SD)*	*Mean number per km (SD)*
Blouberg	M	APTR	1·3	978 (438)	724 (324)
Tableview	S	AP R	7·00	1127 (?)	161 (?)
Milnerton	S	APTR	3·55	496 (644)	132 (181)
Granger Bay	R	APTR	0·50	108 (81)	216 (162)
Mouille Point	R	A TR	1·35	113 (78)	84 (58)
Three Anchor Bay	M	A TR	0·60	85 (17)	142 (128)
Rocklands Beach	R	A T	1·15	390 (?)	339 (?)
Miltons Pool	R	A TR	0·55	604 (?)	1098 (?)
Pavilion (Sea Point)	R	A TR	0·40	1330 (1142)	3325 (2855)
Sunset Beach	M	AP R	0·35	462 (359)	1320 (1026)
Queens Beach	M	AP R	0·45	117 (89)	260 (198)
Saunders Beach	M	AP	0·45	62 (22)	138 (49)
Clifton	S	APTR	1·85	3181 (3573)	1719 (1932)
Maidens Cove	M	APTR	0·75	1422 (1892)	1896 (2523)
Glen Beach	S	APT	0·65	398 (486)	612 (748)
Camps Bay	S	APTR	0·95	1977 (2325)	2081 (2447)
Hottentotshuisie	R	APT	0·80	255 (115)	318 (144)
Llandudno	S	APT	1·25	456 (389)	365 (311)
Sandy Bay	S	I	2·70	339 (145)	126 (54)
Hout Bay	S	APTR	1·35	1048 (1080)	776 (800)
Kommetjie	R	IPTR	2·35	163 (104)	69 (44)
Soetwater	R	IPT	4·40	1143 (948)	260 (215)
Witsand	S	IPT	1·20	71 (?)	59 (?)
Scarborough	M	IP	2·05	72 (59)	35 (29)
Buffelsbay	R	IPT	1·10	227 (45)	206 (41)
Bordjiesrif	R	IPT	1·15	391 (?)	340 (?)
Miller's Point	R	IPT	1·60	311 (187)	194 (117)
Windmill Beach	M	IPT	0·85	110 (21)	129 (25)
Boulders	M	IPT	0·65	272 (30)	418 (46)
Seaforth	M	IPRT	0·40	319 (93)	797 (233)
Long Beach (Simon's Town)	S	APT	2·15	441 (559)	205 (260)
Makrielbay (Simon's Town)	M	APT	0·95	19 (?)	20 (?)
Glencairn	S	APT	1·30	48 (35)	37 (27)
Fish Hoek	S	APTR	1·80	795 (520)	442 (289)
Kalk Bay	M	APTR	0·95	546 (449)	575 (473)
Dalebrook	M	AP	0·55	119 (87)	216 (158)
St James	M	APTR	0·65	437 (360)	672 (554)
Muizenberg	S	APTR	1·40	3422 (4961)	2444 (3544)
Sunrise	S	APTR	8·25	1309 (1658)	159 (201)
Strandfontein	S	APTR	6·55	4762 (8640)	727 (1329)
Mnandi	S	APTR	2·20	3901 (6032)	1773 (2742)
Monwabisi	S	APTR	7·65	860 (672)	112 (88)

[a] R = Rocky; M = mixed; S = sandy.
[b] A = Accessible; I = inaccessible; P = parking; T = toilet; R = refreshments.
Source: Metplan.

Fig. 2. Aerial photograph of St James tidal pool on the western shores of False Bay.

To enhance the recreational appeal of the shoreline, a number of amenities have been provided. These include tidal pools to provide safe bathing. Originally, tidal pools were only built on rocky shores (e.g. St James (Fig. 2), Dalebrook) and tended to be relatively small. Recently, however, two giant pools have been built along the sandy northern

Fig. 3. Aerial photograph of Strandfontein tidal pool on the northern shores of False Bay.

shores of False Bay at Strandfontein (Fig. 3) and Mnandi, and are intended to cater for the recreational needs of the rapidly growing population on the Cape Flats.

Other amenities already provided include parking areas, showers, life-saving facilities, litter bins, changing booths, toilets, cleansing services and both fixed and mobile refreshment stands. Many of the smaller tidal pools are also drained, cleaned and painted with lime on a regular basis. The large, recently built tidal pools form part of fully planned coastal recreational centres that include parking, landscaped picnic and barbecue areas, playgrounds, and pavilions housing restaurants and entertainment centres.

Spatial patterns

Peak 'non-exploitative' utilization of the Western Cape shoreline is concentrated on sandy beaches with a mean density of 1777 visitors per km of beach at survey times, Muizenberg having the highest density with a mean number of 2444 visitors per km (Table 2). Although the Sea Point Pavilion had the highest density of visitors with a mean of 3325 people per km, these people are not utilizing the shore as such. The availability of safe bathing facilities, whether due to the presence of tidal pools (e.g. Miltons' Pool, Sea Point Pavilion, Strandfontein, Mnandi) or not (e.g. Clifton, Hout Bay, Fish Hoek, Muizenberg), results in high densities of people visiting the shore. Other aspects, such as wind shelter, accessibility, proximity to residential areas, parking availability, ablution facilities, and refreshment kiosks, are also important in areas having high attendances.

Temporal patterns

Beach attendance is affected considerably by prevailing weather conditions,[8] so that peak attendances are only observed during peak holiday seasons when the weather is suitable and especially between 10.00 and 16.00 (Fig. 4). The results obtained by aerial survey represent numbers of visitors to a beach at a particular point in time. This is not necessarily a reflection of the maximum number of people present on the beach on that particular day and certainly not of the total number of visitors, since few people remain on the beach for more than three hours.[8]

Surprisingly, beach attendances on Saturday 19 December 1987 were low, with a mean density of 70 people per km over the 141 km coastline surveyed (i.e. 42% attendance compared to attendance on 10 January

TABLE 3
Densities of Beach Attendances along the Entire Coastline of the Study Area on Surveyed Days

Section of coastline	*Length of beach (km)*	*Density (number/km)*[a]					
		2 Jan. 1985	*1 Jan. 1986*	*26 Dec. 1986*	*19 Dec. 1987*	*1 Jan. 1988*	*10 Jan. 1988*
Gordon's Bay–Strand	5·8	—	—	—	162	926	446
Macassar–Sunrise	6·0	327	1025	550	15	1072	98
Muizenberg–Fish Hoek	7·6	571	1868	1180	133	722	195
Fish Hoek–Cape Point	29	56	98	207	—	135	—
Cape Point–Kommetjie	35	41	45	93	2	—	20
Kommetjie–Cape Town	44·3	177	593	245	54	977	142
Cape Town–Blouberg	13·0	—	259	146	55	75	106
Total	140·7	234	648	404	70	651	168

[a] Densities of beach attendance along the penninsula coastline at 13.00 to 15.00 h on six days during peak holiday periods between 1985 and 1987/88.

ACKNOWLEDGEMENTS

The authors would like to thank the Sea Fisheries Research Institute for providing research funds. The Town Planning and Metplan divisions of the Cape Town City Council have been extremely helpful and kindly provided much of their aerial survey data for this report. The aircraft pilot, Dane Gerneke, also deserves thanks for his enthusiastic cooperation in this survey.

REFERENCES

1. Anderson, S. H., The role of recreation in the marine environment. In *Ocean yearbook 2,* ed. E. M. Borgese & N. Ginsburg. The University of Chicago Press, Chicago, 1980.
2. Heath, R., *Impact of trampling and recreational activities on the littoral active zone—a literature review.* Institute for Coastal Research, University of Port Elizabeth, Report No. 15, 1987.
3. Anon., *Age by development region, statistical region & district central statistical services.* Republic of South Africa population census 1985, Pretoria, Report No. 02-85-02. September 1986.

4. Anon., *Projections of the population of the Cape Town land use/transport study area 1980–2000.* Metropolitan transport planning branch, City Engineer's Department, Cape Town, June 1986.
5. Sowman, M. R., *An assessment of recreational carrying capacity at Infanta, Southern Cape.* University of Cape Town School of Environmental Studies, Research Report No. 57, 1984.
6. Sowman, M. R., A procedure for assessing recreational carrying capacity of coastal resort areas. *Landscape and Urban Planning,* **14** (1987), 331–44.
7. Beavon, K. S. O., *Greater Cape Town region recreation and tourism.* Provincial Administration of the Cape of Good Hope, Planning Report No. 5, 1968.
8. van Herwerden, L., Bally, R., du Plessis, C., Blaine, M. & Griffiths, C. L. Shore utilization patterns in a metropolitan area, the Cape Peninsula, South Africa. *Ocean & Shoreline Management* **12**(4) (1989).
9. Bally, R., Brown, A. C. & McQuaid, C. D., Shores of mixed sand and rock: An unexplored ecosystem. *S. Afr. J. Sci.,* **80** (1984) 500–503.
10. Boden, R. W. & Ovington, S. D., Recreation use––patterns and their implications for management of conservation areas. *Biol. Conserv.,* **5** (1973) 265–70.

Chapter 3

Patterns of shore utilization in a metropolitan area, the Cape Peninsula, South Africa

(Published in Journal of Ocean and Shoreline Management 12 (4) in press)

Patterns of shore utilization in a metropolitan area, the Cape Peninsula, South Africa.

Abstract:

A survey of the western shores of False Bay, Cape Peninsula, South Africa (34°5'S, 18°26'W - 34°9'S, 18°29'W) was undertaken to determine patterns and intensities of human utilization over a one-year period. This was done as part of a programme to monitor the impact of proclaiming three small marine reserves (created in March 1986) along this intensively utilized stretch of coastline. Only 6% (48 000) of all visitors to the shore were exploiters ie. anglers and baitgatherers. The greater proportion of visitors (779 640) engaging in non-exploitative recreational activities that were concentrated at sandy beaches. Mean daily shore attendances peaked between 12h00 and 16h00. Numbers of visitors during "out-of-season" periods peaked over week-ends; with Saturdays being more popular than Sundays. Wednesdays were found to have unexpectedly high attendances. Maximum overall beach attendances occured during the peak holiday season (Christmas holidays), but over this period weekday attendances exceeded those over week-ends. Factors influencing the utilization patterns are discussed.

Introduction:

Advanced technologies and the concomitant overall increase in the standard of living contribute to increased leisure time available for people to pursue recreational activities (Anderson 1980). Due to the temperate and warm South African coastal climate many people participate in recreational activities along our shoreline.

Recreation is defined as "any pleasurable interest or form of physical excercise divorced from one's daily work or routine" (Collins 1956) and outdoor recreation is playing an increasing role in the lives of metropolitan people in search of better recreational prospects at a reasonable distance (Benthem 1973).

Conservation of the intertidal zone has been defined as the wise utilization of the intertidal (Gaigher 1979), eg. by the institution of policed reserves to protect resources or by allowing non-detrimental exploitation as prescribed by legislation controlling exploitation (Table 3.1).

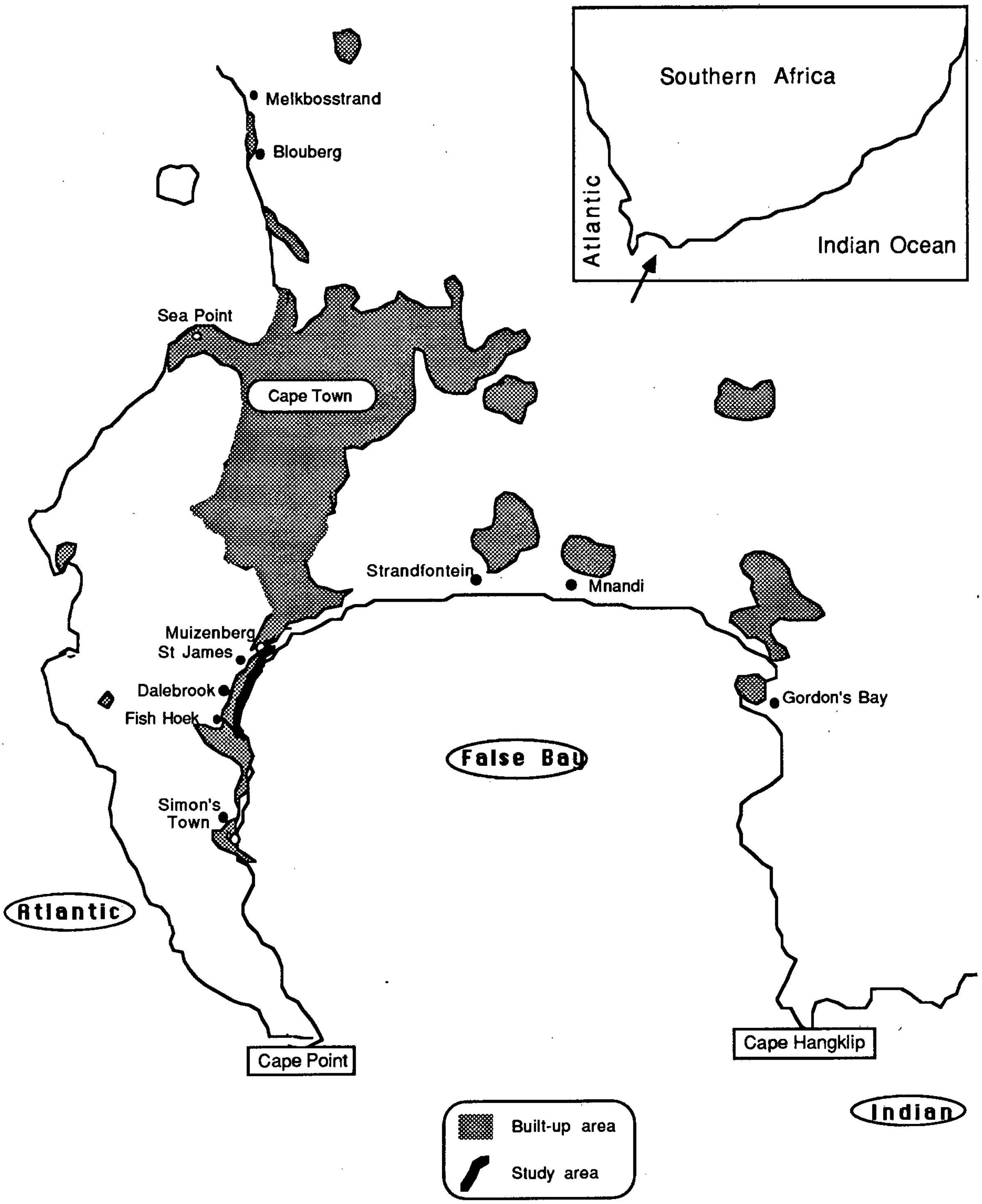
Among many reasons for conservation is the need to provide protected or buffer areas for exploited species, thereby maintaining the natural populations for educational and scientific purposes on the one hand, as well as for recreational purposes on the other. There is thus an inherent contradiction in the creation of reserves which attempt to retain an unspoilt environment, whilst making provisions for tourism and recreation (White & Bratton 1980). The greatest threat to conservation is the human effect - direct or indirect. Threats to ecosystems in reserves include visitor pressure, impact of collectors, gatherers and fishermen, as well as the lack of effective management policies. In order to protect such reserves from over-utilization it is essential to have management policies that are based on the achievement of stated goals, the implementation of which is moulded by the outcome of scientific monitoring and research.

Whilst naturalness implies freedom from human influence, very few, if any, communities are free from such influence, so that

Table 3.1: Restrictions on popular shellfish and bait organisms (Sea Fisheries Research Institute)

Species	Minimum size (cm)	Maximum number
Alikreuk (Turbo samaticus)	6.35	10
Armadillo (Dinoplax gigas)	-	6
Black mussels (Perna, Choromytilus)	-	25
Bloodworm (Arenicola loveni)	-	5
Clams	-	8
Crab (Scylla serrata)	11.43	2
Limpets (Patella sp.)	-	15
Octupus	-	2
Oyster	5.08	25
Periwinkle (Oxystele)	-	50
Polychaetes	-	20
Prawns (Penaeus)	-	50
Redbait (Pyura sp.) (kg)	-	1.8
Sea cucumber (Holothuria sp.)	-	20
Sea urchin (Parechinus sp.)	-	20
Siffie (Haliotis spacidae)	3.175	10
White mussels (Donax serra)	3.5	50

Figure 3.1: Map showing study area in relation to South African coastline



the extent of the influence becomes critical. In Britain and Europe there are no natural areas to serve as control areas for baseline studies against which change in disturbed areas can be measured, so that naturalness cannot be clearly defined (Margules & Usher 1981).

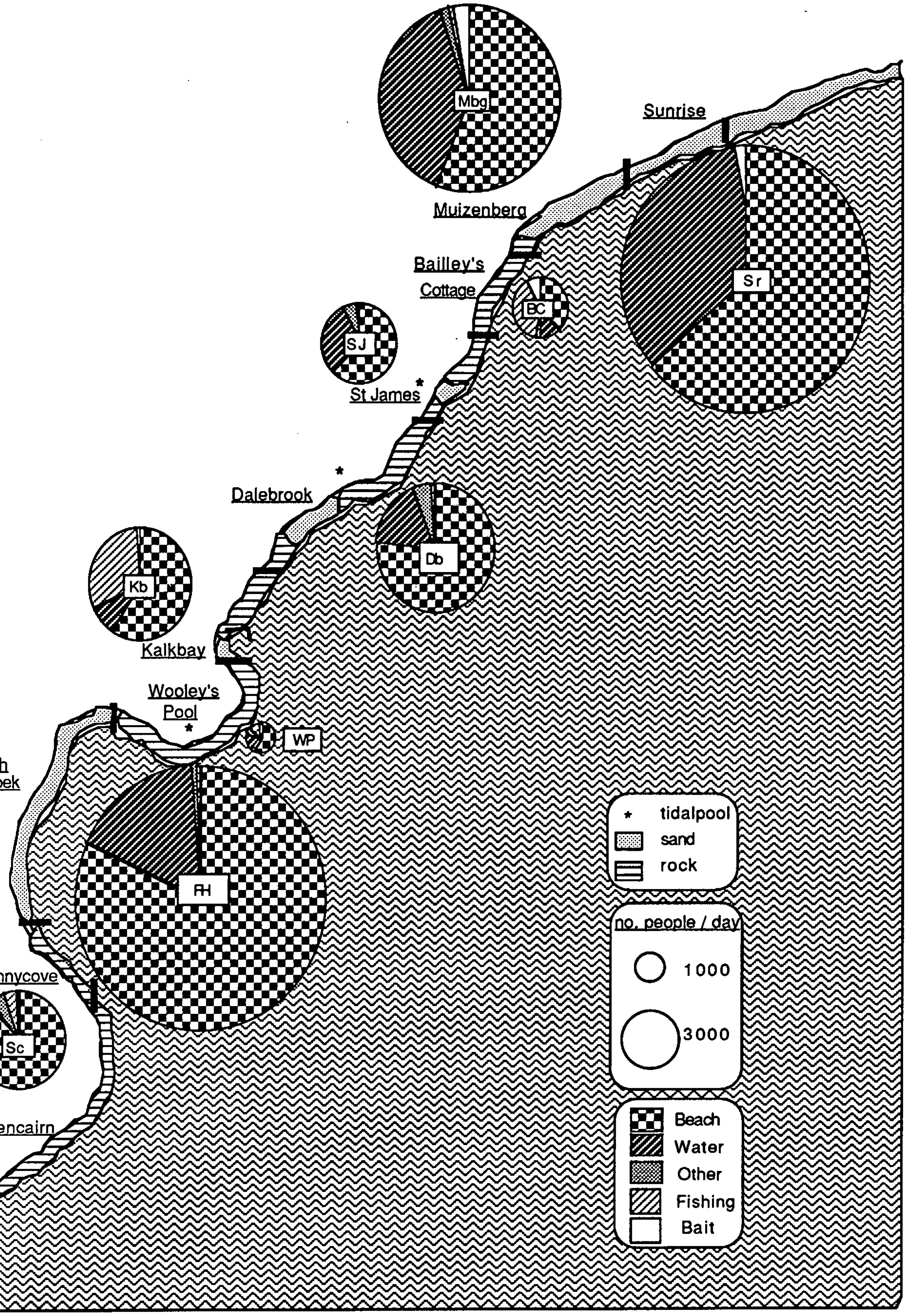
As it is difficult to remove the human influence from reserves, monitoring of both direct and indirect impacts, as well as changes that are occurring naturally in the communities must form an integrated part of the management policy.

This study aims to evaluate the patterns and intensities of human activity that impact both directly and indirectly on the shoreline of the study area, which covers a stretch of coastline that was given conservation status in 1986.

Study site and methods:
The study area covers a 7.6 km stretch of coastline (Fig. 3.1) along the western shores of False Bay, 66% of which is rocky shore and 34% sandy beach. This area has been divided into sections that have one of three grades of conservation status, ie.: totally protected reserve (St James to Kalk Bay); partially protected reserve where fishing by rod and reel is permitted (Muizenberg Corner to St James; Sunnycove to Glencairn); and areas where no restrictions other than the general exploitation legislation (size and bag limits - Table 3.1) apply (Sunrise to Muizenberg Corner; Kalk Bay to Sunnycove)(Fig 3.2).

The shoreline was surveyed on 68 days spread throughout the year; on 37 of these days counts were made every 2 hours from 6h00 to 20h00 and on 31 days counts were done only at 8h00, 14h00 and 18h00. Surveys were undertaken in all weather conditions on

Figure 3.2: Map showing activity distribution at all sites surveyed within study area



weekdays, week-end days, public holidays (Easter) and annual holidays (Christmas period) and covered all tidal states in the spring to neap tide cycle. Summer was considered to cover the period October to April, while winter was considered to be from May to September. At each of nine sites the number of people engaged in a particular activity at the survey time was recorded. Observed activities were: sunbathing, passive recreation, natural history, walking, cleaning (municipal workers removing litter from the shore), surfing (inclusive of windsurfing and paddleskiing), swimming, boating, snorkelling, scuba diving, spearfishing, fishing and bait gathering. Observations were made of times spent on the shore by people engaged in each of these different activities over 5 consecutive days and at different sites. From these values a table of correction factors was drawn up from which it was possible to calculate the total number of people visiting the shore to engage in any particular activity on any given day (Table 3.2).

Results:

Spatial patterns of shore utilization:

The most frequented of all sites surveyed was St James, a small pocket beach possessing a tidal pool. Generally, however, the most intense shore utilization occurred at the sandy beaches, which account for 34% of the shoreline in our study site, the remaining 66% being rock (Table 3.3). Beach activities such as sunbathing, passive recreation and walking occupy 69% of all the visitors to the study area, while 23% are engaged in water-based activities such as surfing sports, swimming, snorkel and scuba diving and boating (Fig 3.2). Only 6% of all shore utilizers in our study area were engaged in exploitative activities such as

Table 3.3 Description of sites within the study area and the intensity of use

SITE	TYPE *	CONSERV. **	DENSITY nr/km/yr
SUNRISE	S	-,-	274040
MUIZBRG	S,R,G	-,-	156558
BAILLEYS	R	+,-	34417
STJAMES	S,R,G	+,+	362209
DALEBRK	S,R	+,+	60907
KALKBAY	S,R	-,-	152903
WOOLEYS	R	-,-	9265
FISHHK	S	-,-	168555
SUNNYCVE	R,G	+,-	138367

* S=sand, R=rock, G=grass.
** Conservation status:
-,- = no reserve
+.- = angling permitted
+,+ = reserve

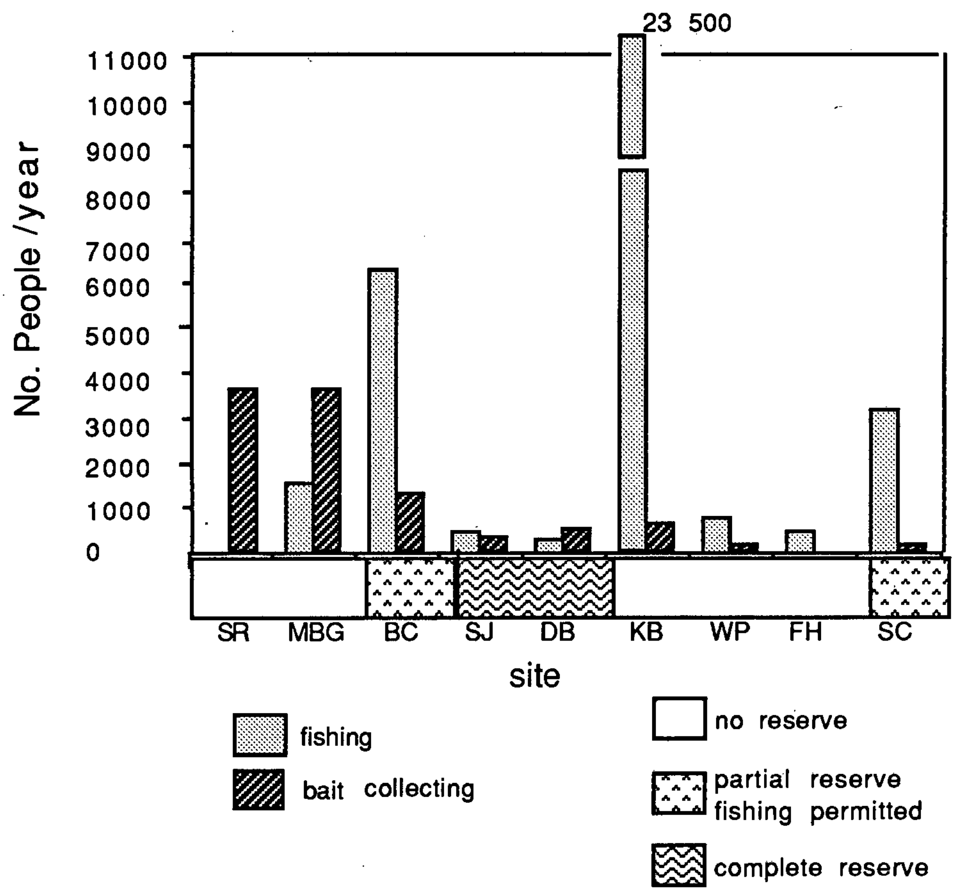
fishing, spearfishing and bait gathering.

However, even this figure of 6% is equivalent to 48 000 people per year, ie. on average 132 people per day were engaged in exploitative activities along the 7.6 km shoreline of our study area alone. Anglers account for 83% of all exploiters, the remaining 17% being bait gatherers. Moreover, further analysis showed that a mean value of 8 people per day, ie. 6% of all exploiters were engaged in illegal exploitation of which 24% were angling in complete reserves and 76% were collecting intertidal species such as mussels, siffies (Haliotis), musselworms (Pseudonereis) and redbait (Pyura spp.) within the borders of the proclaimed reserves, which have a combined length of 3km, ie. 39% of the study area (Fig 3.3).

Fishing with rod and reel occurs only along the rocky shores of the study area, Kalk Bay being the most popular site, great numbers of fishermen casting off the wall of the fishing harbour.

Bait gathering on the other hand is mostly done along the sand shores of Sunrise and Muizenberg, where bloodworm (Arenicola loveni) populations occur at LWN (low water neaps). This is a popular bait organism. Other less intensively collected bait organisms include redbait (Pyura stolonifera), mussel worm (Pseudonereis spp.) and tube worm (Gunnarea capensis), all of which inhabit rocky shores. Barnacle spp. (Cthalamus, Tetraclita) are sometimes used as groundbait by fishermen, ie. the barnacles are scraped from the rock and thrown into the water to attract fish. Mussel species within the study area are mostly subtidal, so that they are not a target species for exploitation, though at Bailley's Cottage there is a fairly extensive mussl bed, which is exploited for food. Monitoring of the intertidal communities

Figure 3.3: Distribution of exploitative activities throughout study area



along the rocky shores of the study area need to be continued for several years before any changes will be detectable in the intertidal populations of this area.

Temporal patterns of shore utilization:

Mean daily beach attendances for the entire year of 1987 along our shoreline were found to peak between 12h00 and 16h00 (Fig 3.4). Whereas the summer peak was broad, stretching from 12h00 to 16h00, the winter peak rose sharply at 12h00 and dropped again soon thereafter. There was a dramatic decrease in the number of people attending the shore during winter, and the period over which visits occured was also abbreviated because of the shortened day length. Where people were already present from 6h00 in summer and stayed until 20h00, they only appeared from 8h00 in winter and left by 18h00 (Figs. 3.4, 3.5a).

When comparing weekly utilization patterns differences are evident between holiday and non-holiday periods. Outside the holiday season weekday counts were much lower than those over weekends, with Saturday showing the maximum attendance figures. Unexpectedly, the mean beach attendances for Wednesdays in summer are noticably greater than those on other week days. Monday to Friday counts are much greater during holidays, exceeding those over weekends. Saturday and Sunday counts were in fact lower during holidays than they were "out-of-season" since at that time weekends are the only days most users are free to attend the beach (Fig 3.5b). Trends in the annual pattern of utilization (Fig 3.6) were that weekday beach attendances were greatest during the annual December, or Christmas holidays, while week-end beach attendances were maximal in the summer months of January, February and March (Fig 3.6a,b), where they rose to as much as 3422

Figure 3.4: Mean hourly distribution of all activities surveyed during one year within the study area

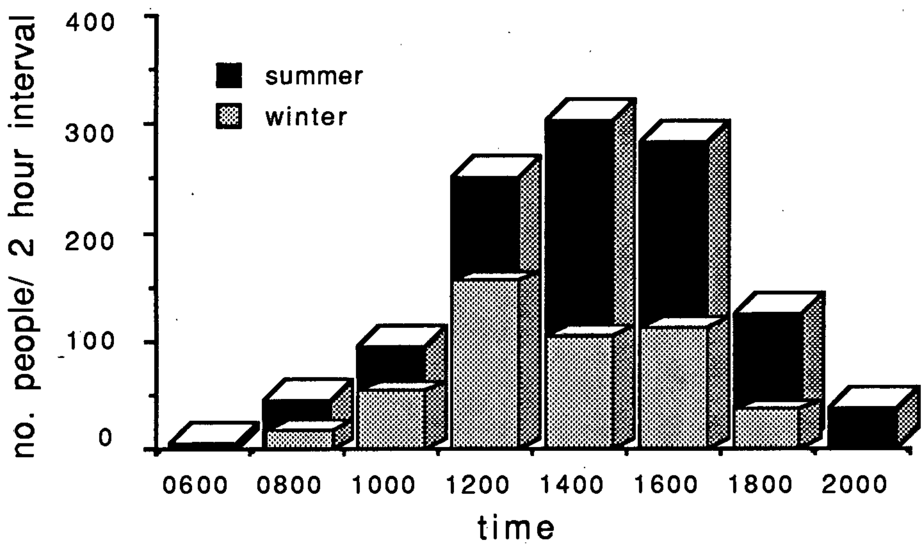


Figure 3.5a: Mean seasonal distribution of all observed activities at all sites within the study area

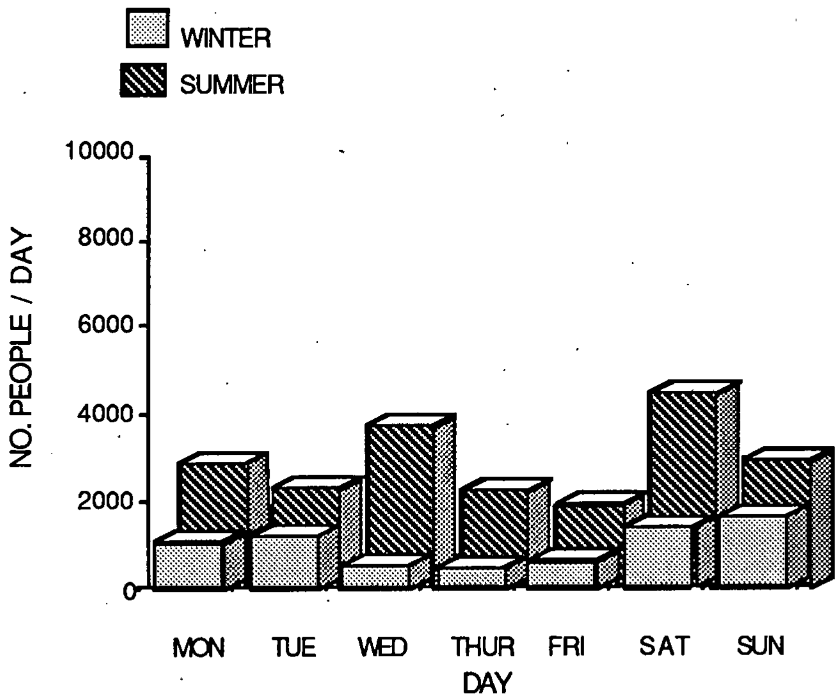


Figure 3.5b: Mean distribution of all activities in the study area during normal summer days as opposed to summer holidays

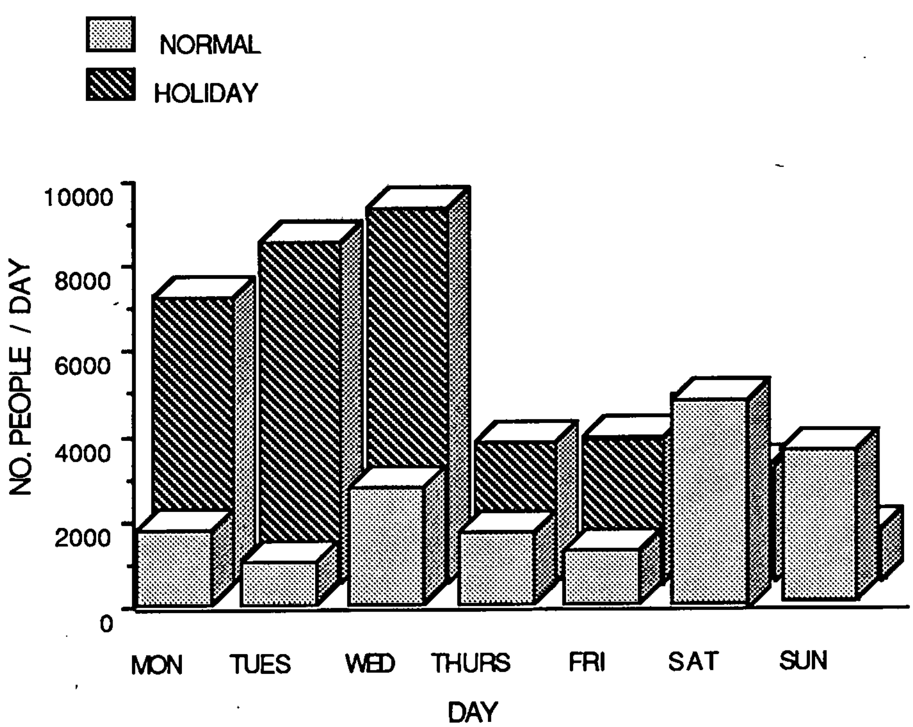


Figure 3.6a: Mean monthly distribution of shore use throughout one year on week days

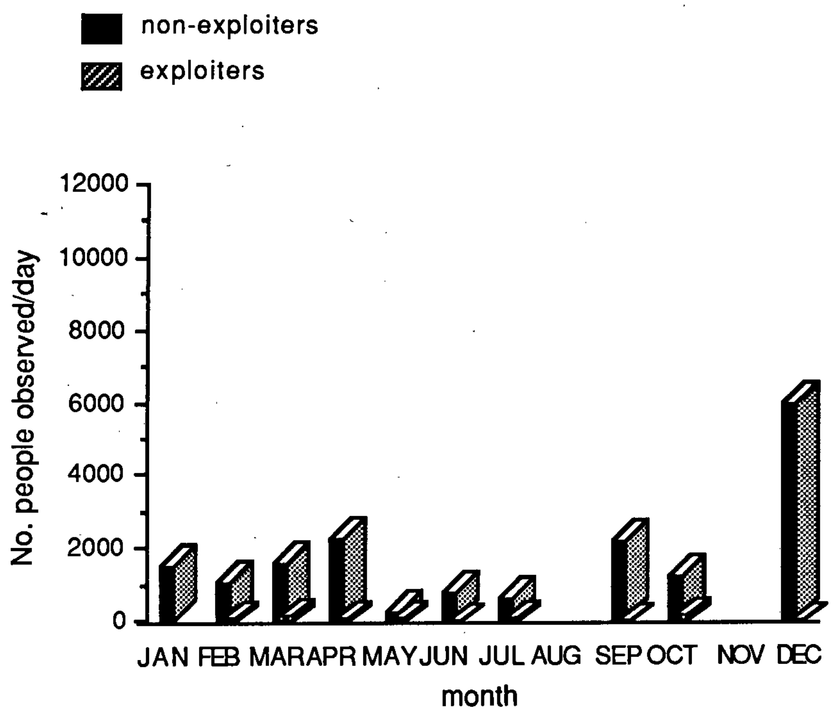
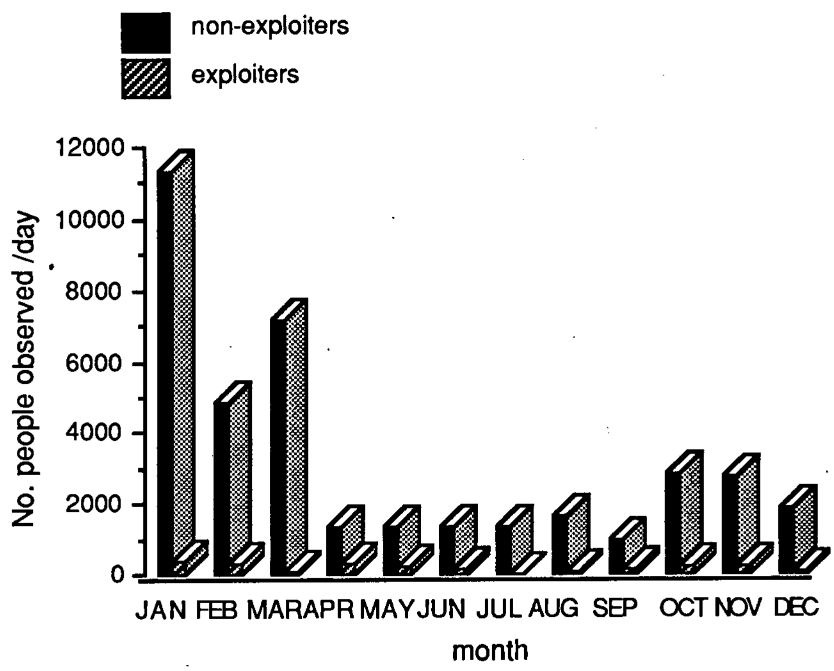


Figure 3.6b: weekends only



or 2444 persons per km of shoreline at a particular point in time (Sea Fisheries Research Institute 1988).

T-tests were done to test for the significance of differences ($p=0.05$) in the mean numbers of people participating in various activities (Table 3.4) and it was found that the most significant differences that occured were between summer and winter for all beach activities, wheras water activities, except swimming showed no significant differences in intensity between summer and winter ($t < 1.997$). Interestingly, no significant differences occurred in the intensity of any of the activities on days during spring tides and neap tides ($t < 1.997$). There was also no significant difference between the intensities of activities on Wednesday against Saturday or Sunday, ($t < 2.074$).

Discussion:

In the present study, the tendency for beaches to be more popular than rocky shores seems to be directly linked to the nature of public activities. Most people partake in beach-related activities such as sunbathing, passive recreation and walking when visiting this shore; also most water-related activities such as swimming and surfing sports are favoured by the absence of rocks. Sunrise and Muizenberg form one continuous, long beach, which together with Fish Hoek beach are provided with good parking and recreational facilities, when compared to other sites in the study area, where parking and other facilities are fairly limited. The entire study area is served by a railway line connecting Cape Town to Simonstown (south of the study area), and all sites are within close walking distance of a railway station. The coastline is, however, exposed to southeasterly winds in summer and northwesterly winds in winter. StJames is a small

Table 3.4: t-statistics for various activities, those greater than the critical value are significant at the 5% level

	Critical t-value	WALK	SUNBATHE	PASSIVE RECREATION	SURF	SWIM	BOAT	NATURAL HISTORY	SNORKEL DIVE	SCUBA DIVE	SPEAR-FISH	FISH	BAIT GATHER	CLEAN	TOTAL
S vs W	t > 1.997	*3.375	*3.102	*4.168	0.013	*4.185	0.921	*2.194	*2.963	0.413	1.018	*2.496	1.437	1.97	*4.301
sp vs np	t > 1.997	0.602	1.368	0.953	0.895	0.407	0.253	1.198	0.625	1.135	1.549	1.26	0.262	1.192	0.831
Wed vs w/e	t > 2.074	1.494	1.814	1.398	1.899	1.368	1.192	1.357	1.428	1.539	0.761	1.57	1.432	1.217	1.245

S vs W = Summer vs Winter, sp vs np = spring tides vs neap tides, Wed vs w/ = Wednesdays vs week-end days.

* t > t-critical

pocket beach of mixed sand and rock, which is also sheltered from the wind in both seasons to a fair extent. A tidal pool also provides for safe bathing, so that this is the most popular beach in the study area, despite a relative lack of parking.

Rocky shores are easily exploited systems (van Herwerden & Bally 1989, Siegfried et al 1985, Moreno et al 1984, Beauchamp & Gowing 1982). Hockey and Bosman (1986) showed in their study along the Transkei coast that exploitation led to a common state, ie. a convergence in the community structure, despite differences that existed between communities of non-exploited sites.

Beach attendances peak between 12h00 and 16h00, 14h00 being the busiest time on beaches in the western Cape, as Beavon (1968) also found in his survey of the Cape Metropolitan beaches. A definite dichotomy in shore utilization pressure exists between summer and winter:- summer days being long, warm and sunny are much preferred to the short, wet and cold days of winter. These findings indicate the importance of weather conditions to shore recreationists. Duran et al.(1987) found that there was an increase in the mean number of subsistence exploiters during the Chilean summer (December to March) and deduced that the trend was due to the increased human population of the coastal zone during this time of year, because of the favorable climate of the Southern Hemisphere during summer, coinciding with summer holidays.

This study also shows that social patterns are important in the determination of the intensity of shore utilization. Thus "in season" (annual summer holidays) the use of the shore is intense during weekdays when compared to weekdays out-of-season. However, weekends in season are less intensively utilized than out of season weekends in summer (January to March). This last finding is unexpected, but is not due to weather effects on weekend survey days in December, compared to weather on weekend days in other summer months (Table 3.5). It may be that people have sufficient opportunities to visit the shore during the week in season, so that the weekends are less utilized. Out-of-season weekends, however, are favoured, as social patterns dictate recreational deprivation for most people during the week. Also Wednesdays, which seem to be more popular than other weekdays in summer, may be as a result of social pattern, as several schools and other training institutions close on Wednesday afternoons, giving more people an opportunity to visit the shore.

Favoured activities during summer were found to be walking, sunbathing, passive recreation, natural history, swimming, snorkelling, and fishing, whereas surfing, boating, scuba diving, spearfishing, baitgathering and beach cleaning showed no correlation with the seasons ($t < 1.997$). Surprisingly, different tidal phases did not seem to favour certain activities ($t < 1.997$). Duran et al. (1987) found in Chile that shore exploitation activities correlated significantly with low tides, whereas diving did not . Bigalke (1983) found in Transkei that exploiters were only active during spring low tides , but not normal low tides. One reason for the lack of correlation in this study may be that there are not many subsistence exploiters active in the study area, whereas in Chile and Transkei most exploiters are subsistence gatherers. The fact that weather conditions rather than temporal conditions prescribe the favored activities should explain the lack of correlation between different activities and different days of the week.

Table 3.5: Weather data for summer week-end days surveyed in 1987.

DAY	CLOUD (%)	RAIN (mm)	WIND DIRECTION	WIND SPD. (m/s)	MINIMUM TEMP. (C)	MAXIMUM TEMP. (C)
31.01.87	63	0	S	8.8	12.5	18.1
01.02.87	100	20	NW	7.5	18	22.4
15.02.87	48	0	S	9.3	15.2	20.5
28.02.87	67	0	NW	7.5	16.6	24.8
15.03.87	64.7	0	SW	5.8	12.5	19.2
11.04.87	12	0	SE	12.7	13.7	18.2
25.04.87	33.7	0	E	2.5	13.5	19.8
26.04.87	21	0	SE	6.8	13	20.2
27.09.87	100	0	SE	4.5	19	23
03.10.87	71	0	NW	7.2	13.3	18.8
18.10.87	50	0	S	8.3	13.2	20.2
01.11.87	9	0	SE	10.5	10.9	18
14.11.87	79	0	W	4.5	12.3	17.8
12.12.87	34	0	SE	13.8	12.3	18.2
13.12.87	30	0	S	8	13.6	20.5
MEAN (+/-SD)	52.16 (28.02)	1.3 (5.16)	SE (SSW-ESE	7.8 (0.78)	14 (2.26)	20 (2.06)

The first marine reserve in Britain (at Lundy) was established in October 1986. Limited restrictions apply here and it has been found that cooperation is the key to maintaining an effective reserve (Kayes 1987). It has also been found to be more difficult to manage busy areas than rather remote areas - factors that we have perceived to apply in the metropolitan area of this study as well.

Conclusions:

The compatibility of the multidimensional usage of marine resources must be considered when declaring marine reserves. As is the case in our study area, however, when making management decisions it must be kept in mind that natural areas have a limited carrying capacity as to how much ecological and sociological pressure an area can withstand (Sowman 1987). In a study of conservation along the Tanzanian coast Bryceson (1981) concluded that marine reserves could be fished by non-harmful traditional techniques, provided that some sanctuaries existed.

All factors discussed in this report need to be considered - not only in the conservation areas along the metropolitan western shores of False Bay, but along the entire South African and other coastlines.

Acknowledgements:

Many thanks to Karen Harmer for assistance in the field. Dr. R. Bally assisted in the field and advised during the write - up of this chapter and I thank him. Thanks are also due to the Sea Fisheries Research Institute for providing funds to make this study possible.

Chapter 4

Assessment of marine conservation awareness of the general public

Assessment of marine conservation awareness of the general public.

Introduction:

A questionnaire survey was undertaken in 1987, by interviewing people present on the shore of the study area, shortly after the marine reserves in False Bay had been declared. The same survey was repeated in 1989, after new signposts had been erected in the conservation areas along the shore. These surveys were undertaken to obtain an insight into public awareness and support of marine conservation along the False Bay shoreline at the outset of the study, and later to determine whether there had been an increase in the public awareness of marine conservation in False Bay, both after the passage of time and after the erection of improved signposts at conservation areas.

Study area and methods:

A questionnaire sheet was drawn up under the expert guidance of M. Sowman (School of Environmental Studies, University of Cape Town) (Appendix 1). The survey was undertaken by interviewing individuals of the public, while present on the shore, from Sunrise Beach (east of Muizenberg) to Jager's Walk (south of Fish Hoek). During 1987, 98 individuals were interviewed while 99 respondents were interviewed during 1989. The questionnaire sheets were then coded and the data was analyzed using contingency tables (BMDP2d) and Chi square statistics (BMDP4f). Analysis of variance were not performed on the data, as the data did not meet the assumptions.

Results:

The results of the 1987 and 1989 surveys are summarized in Tables 4.1 a and b and shows the following: In 1987 respondents from Greater Cape Town represented 64% of the sample, while 77% of the 1989 sample were respondents from the Greater Cape Town region. The majority of respondents in both 1987 and 1989 did not select a particular time of day or tidal state to visit the shore. Approximately 95% of the respondents in both surveys engaged in passive recreation while visiting the shore, the remaining 5 percent of people engaging in exploitative or potentially exploitative activities. Most people in both surveys did not collect anything while visiting the shore (54% in 1987 and 62% in 1989), while those people that did collect something were mostly shell gatherers (approximately 35%) in both instances. The reason given by most respondents for collecting specimens on the shore is for nature study or display, while in both instances 5 - 6% percent of people collecting living things use them as bait or food. Of all the people interviewed, 15% (in both 1987 and 1989) do some diving; of these divers 3 and 6% (1987 and 1989 respectively) are spearfishermen, while 8 and 4% (for 1987 and 1989) collect food organisms such as rock lobster (Jasus lalandii), perlemoen (Haliotis midae) and alikreukel (Turbo sarmaticus). However, the collection is not done within the study area of this survey, but elsewhere along the Southwestern Cape coast. In 1987 there were 50% of the respondents that claimed to know of the marine conservation areas in False Bay, while 63% of the 1989 respondents claimed knowledge of the marine reserves in False Bay. However, 84% of the 1987 respondents and 56% of those interviewed in 1989 could not name any of the areas that are marine reserves in False Bay. The overwhelming number of respondents (93 - 94%) in both surveys support marine

Table 4.1a: Statistical breakdown of 1987 questionnaire components, using contingency tables (BMDP2d)

Category	Variables (% of respondents)				
Place of residence	Greater C.T.	W.Cape	Elsewhere S.A	Elsewhere	
	64.3	2	28.6	5.1	
Season of visit	Summer	Winter	All year		
	51	3.1	45.9		
Visiting frequency	Daily	> 1Xweek	> 1xyear	Ann. leave	First visit
	25.5	39.8	13.1	14.3	7.1
Visiting time (of day)	Morning	Afternoon	Evening	Any	
	27.6	13.2	4.1	55.1	
Tidal phase preferred	High	Low	Any		
	5.1	6.1	85.7		
Reason for visit	Close to home	Amenities	Activities	Other	
	29.6	29.6	27.6	13.2	
Activity engaged in	Passive recr.	Exploitation	Potential expl.		
	92.9	2	5.1		
Party composition	Single	Couple	Family	Other	
	30.6	27.6	34.7	7.2	
What is collected if anything	Nothing	Shells	Animals		
	54.1	37.8	8.2		
Where collected from if anything	N/A	From beach	elsewhere		
	54.1	30.6	15.3		
Reason for collecting	N/A	Display	Nature study	Food/Bait	Other
	53.1	19.4	13.3	6.1	8.1
Divers only: spearfisherman	N/A	Yes	No		
	84.7	6.1	9.2		
Divers only: other exploitation	N/A	Yes	No		
	86.7	8.1	5.1		
Knowledge of conservation areas	Yes	No			
	50	50			
Ability to name areas	No	Correct	Incorrect		
	83.7	15.3	1		
In support of conservation?	Yes	Indifferent	No		
	93.9	5.1	1		
Do you read signs when on shore *	No	Conservation	Social	saw none	
	73.5	14.3	5.1	8.2	
Adequacy of conservation measures	Adequate	Inadequate	Overdone	Don't know	
	29.6	36.7	1	32.7	
Comment if any	None	Too late	Must enforce	Publicize	Other
	42.9	4.1	16.3	10.2	26.5
Sex of respondent	Male	Female			
	65.3	34.7			
Race group of respondent	White	Coloured	Black		
	93.9	6.1	0		
Age group of respondent	Child	Teen	Adult	Aged	
	1	13.3	58.2	27.6	

* Respondents that answered in the affirmative were then asked to relate the information gleaned from the signs, these answers were then categorised as follows:

conservation - any sign relating to marine conservation
social - any sign relating to other activities, eg. ball games, dogs, surfing and swimming areas.

Table 4.1b: Statistical breakdown of 1989 questionnaire components, using contingency tables(BMDP2d)

Category	Variables (% of respondents)				
Place of residence	Greater C.T.	W.Cape	Elsewhere S.A	Elsewhere	
	76.8	3	15.2	5.1	
Season of visit	Summer	Winter	All year		
	51.5	0	48.5		
Visiting frequency	Daily	> 1Xweek	> 1xyear	Ann. leave	First visit
	15.2	15.2	53.6	10.1	6.1
Visiting time (of day)	Morning	Afternoon	Evening	Any	
	23.2	19.2	3	54.5	
Tidal phase preferred	High	Low	Any		
	6.1	8.1	85.8		
Reason for visit	Close to home	Amenities	Activities	Other	
	35.4	4	58.6	2	
Activity engaged in	Passive recr.	Exploitation	Potential expl.		
	98	0	2		
Party composition	Single	Couple	Family	Other	
	26.3	15.2	43.4	15.2	
What is collected if anything	Nothing	Shells	Animals		
	61.6	34.3	4.1		
Where collected from if anything	N/A	From beach	elsewhere		
	60.6	35.4	4		
Reason for collecting	N/A	Display	Nature study	Food/Bait	Other
	60.6	19.2	8.1	5	0
Divers only: spearfisherman	N/A	Yes	No		
	84.8	3	12.1		
Divers only: other exploitation	N/A	Yes	No		
	84.8	4	11.1		
Knowledge of conservation areas	Yes	No			
	62.6	37.4			
Ability to name areas	No	Correct	Incorrect		
	54.5	34.3	11.1		
In support of conservation?	Yes	Indifferent	No		
	92.9	5.1	2		
Do you read signs when on shore *	No	Conservation	Social	saw none	
	31.3	11.2	46.5	1	
Adequacy of conservation measures	Adequate	Inadequate	Overdone	Don't know	
	27.3	25.3	5.1	42.4	
Comment if any	None	Too late	Must enforce	Publicize	Other
	52.5	3	16.2	3	25.3
Sex of respondent	Male	Female			
	54.5	45.5			
Race group of respondent	White	Coloured	Black		
	86.9	12.1	1		
Age group of respondent	Child	Teen	Adult	Aged	
	0	8.1	78.8	13.1	

conservation in principle. In 1987 many more people admitted that they did not read the signposts on the shore (74%), than in 1989 (31%). There were mixed feelings about the adequacy of conservation measures taken in False Bay: in 1987 more people stated that conservation measures were inadequate (37%) than in 1989 (25%), while 33% and 42% (in 1987 and 1989 respectively) did not feel that they were informed enough to make such a judgement. In 1987 1% and in 1989 5% of respondents felt that conservation measures were too restrictive.

On the basis of the above findings, selected categories were subjected to Chi-square analysis. The results, shown in Tables 4.2 a and b, are as follows: In 1987 there were only two categories that were significantly related ($p < 0.05$). Feelings about the adequacy of marine conservation measures were related to place of residence of the respondent (Pearson Chi-square value = 11.029, df = 4, $p < .05$), with locals being more conservation conscious than visitors; and activity engaged in by the respondent (Pearson Chi-square value = 9.902, df = 4, $p < .05$) with exploiters of the shore generally being less positive towards the conservation measures. In 1989 there was a significant relation between place of residence of the respondent and support of the principle of marine conservation (Pearson Chi-square value = 16.724, df = 4, $p < .05$), locals again being more concerned about the conservation of the shoreline than visitors. Place of residence of the respondent was also significantly related to the feelings of conservation adequacy along the False Bay shoreline (Pearson Chi-square value = 10.088, df = 4, p <

conservation measures may be improved on, during the 1989 survey.

Discussion:

Table 4.2a: Pearson Chi-square values for certain variables used in the 1987 questionnaire survey survey using contingency tables (BMDP4f). (x df) the degrees of freedom, * p < 0.05

Activity	1.792 (4df)			
Support	0.74 (4df)	0.492 (4df)		
Adequacy	11.029 * (4df)	9.902 * (4df)	-	
Sex	1.181 (2df)	0.692 (2df)	0.594 (2df)	0.76 (2df)
Age	-	4.251 (4df)	3.541 (4df)	7.523 (4df)
	Residence	Activity	Support	Adequacy

Table 4.2b: Pearson Chi-square values for certain variables used in the 1989 questionnaire survey using contingency tables (BMDP4f) analysis. (x df) indicates the degrees of freedom, * p < 0.05

Activity	1.15 (2df)			
Support	16.724 * (4df)	0.155 (2df)		
Adequacy	10.088 * (4df)	0.878 (2df)	-	
Sex	0.36 (2df)	0.017 (1df)	1.788 (2df)	0.11 (2df)
Age	3.918 (4df)	0.55 (2df)	4.059 (4df)	5.205 (4df)
	Residence	Activity	Support	Adequacy

Most of those interviewed timed their visits to the shore on the basis of suitable weather conditions, rather than selecting a particular time of day or phase of the tide. These findings are supported further by the beach survey undertaken during the course of the entire study (Chapter 3). The proportion of respondents claiming to visit the shore to engage in passive recreation (93%) is also in agreement with the findings of the survey on shore utilization patterns and intensities (Chapter 3), as is the number of exploiters (6%). The agreement between the two survey techniques lends confidence to the values obtained.

There did appear to be an increase in the awareness of marine conservation of the False Bay shoreline from 1987 (50%) to 1989 (63%). However this is probably simply a reflection of the increased proportion of Greater Cape Town residents interviewed in 1989 (77%) than in 1987 (64%).

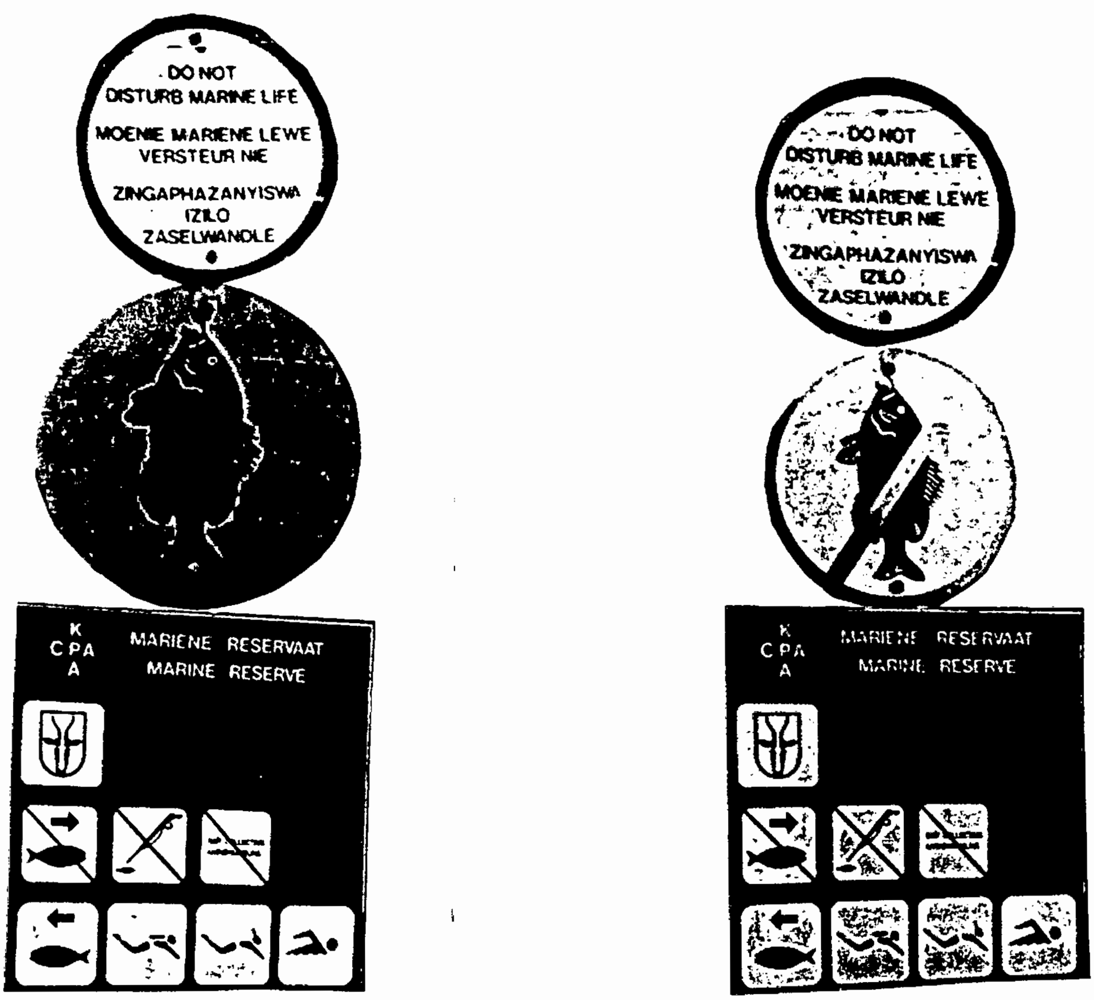
In 1989 more respondents had read the signposts on the shore (69%) than in 1987 (26%). This difference is most likely a result of the erection of better positioned and more comprehensible signposts in the conservation areas during the latter part of 1988 than had initially been placed late in 1986 (Fig. 4.1).

The fairly high proportion of respondents (33 - 42%) that felt unable to comment on the adequacy of conservation measures taken along the False Bay shoreline indicates the very real need for publicizing marine conservation, as people cannot be expected to behave in a "conservation oriented" manner if they are not aware of the conservation measures taken.

As may be expected, respondents that are resident nearer the

Figure 4.1a: Conservation signposts erected during 1986

Figure 4.1b: Conservation signposts erected during 1988



shoreline, as well as respondents engaging in certain activities, such as exploiting the shore, are more likely to be in touch with conservation measures along the False Bay shoreline and have more definitive ideas about the conservation regulations.

Sex and age of the respondent does not seem to affect the "conservation awareness". Unfortunately, the sample does not reflect a random portion of the population, so that no inferences can be drawn about "conservation attitudes" or "conservation awareness" and race.

The single most pronounced comment made by respondents during both 1987 and 1989, was that enforcement of the regulations is neccessary (16%), if the conservation measures are to have any positive effect. Such enforcement need not involve extra government spending, if petty complications are overcome, thereby empowering the law enforcement officers already patrolling the shores to act as honorary fisheries inspectors.

In conclusion, it would appear from this survey that the position and content of the signposts does matter, as more people had read the signs in 1989 than in 1987. Unfortunately, however, further research is needed to establish wether the conservation awareness and attitude of visitors to the shore has increased or improved with the passage of time. Finally - there really ought to be enforcement of the regulations along the False Bay shoreline, as the lack thereof results in a mockery of marine conservation attempts in False Bay.

Acknowledgements:

I am grateful to Ms. G. Burbidge, Ms. M. Blaine and Dr. R. Bally for assisting with the interview of respondents during the course of this survey. Ms. M. Sowman provided her expert guidance during the compilation of the questionnaires and Ms. J. Sommerville was a tremendous help during the BMDP analyses of the data - I thank them.

Appendix 1: Questionnaire - General public.

LOCATION: DATE: TIME:

Preamble: I am conducting a survey for UCT on the utilization of the False Bay coast by the general public. Would you care to answer a few questions?

Question 1: Where do you live? on the False Bay coast ___, in greater Cape Town ___, in the Western Cape ___, elsewhere in S.A. ___, outside S.A. ___

Question 2: Do you mostly visit the False Bay coast: in summer ___, winter ___ or all year round ___?

Question 3: How often do you visit the False bay coast?: daily ___, more than once a week ___, weekly ___, weekends only ___, more than once a month ___, monthly ___, more than once a year ___, annual holidays ___,first visit ___

Question 4a) Do you come at specific times of day: early morning ___, mid morning ___, afternoon ___, evening ___, nighttime ___ or any ___?

4b) Do you come at specific phases of the tide?: high ___, low ___, spring ___, neap ___ tides or any ___.

Question 5: Why do you choose to come to this beach?: close to home ___, amenities/ parking/ transport ___, activity related ___, fishing/ bait/ animal related ___.

Question 6: Which of the following activities do you participate in?

a) When you visit this beach.

b) Generally when visiting the beach.

sunbathing ___, swimming ___, sailing ___, surfing/ windsurfing ___, walking/ walking your dog ___, diving ___, snorkelling ___, fishing ___, bait collecting ___, natural history ___, communing with nature ___, any other (specify) ___.

Question 7: What is the composition of your party?: single ___, couple ___, family ___, larger group(define) ______________________

Question 8a) Do you ever collect shells ___, animals ____, or plants ___ ? Yes ___, No ___.
Where do you collect : from rocks ___ / from rockpools ___/ from the beach ___?
If yes, what? ____
____

Question 8b) If so, what is the purpose? food ___, bait ___, nature study ___.

Question 8c) If you don't take the animals home to eat / use them as bait, what do you do with them?:leave on the beach/rocks ___, throw them in the bin ___, return to rockpools alive ___, return to the sea dead ___.

Question 9: DIVERS ONLY: When you go snorkelling/ diving, do you do any spearfishing? Yes ___, No ___. Do you collect animals? Yes ___, No ___. If yes, what? ______________________________
____

Question 10: Are you aware of the new marine reserves in False Bay? Yes ___, No ___. Could you name the areas? ______________
____
Correct ___, Incorrect ___.

Question 11: Do you support in principle the conservation of the coastline by declaring marine reserves? Yes ___, Indifferent ___, No ___.

Question 12: Did you read the signpost at the entry to the beach? Yes ___, No ___. If yes, do you recall what it said? __________
____
Correct ___, Inncorrect ___.

Question 15: How would you interperet the instruction: "Do not disturb marine life"? ____
____
____
____

Question 16:Do you think that conservation measures along False bay are adequate ___, or inadequate ___?

COMMENTS:
____
____
____

Chapter 5

Comparative densities and size distributions of reef fish at protected and unprotected sites in False Bay

Comparative densities and size distributions of reef fish at protected and unprotected sites in False Bay

Introduction:

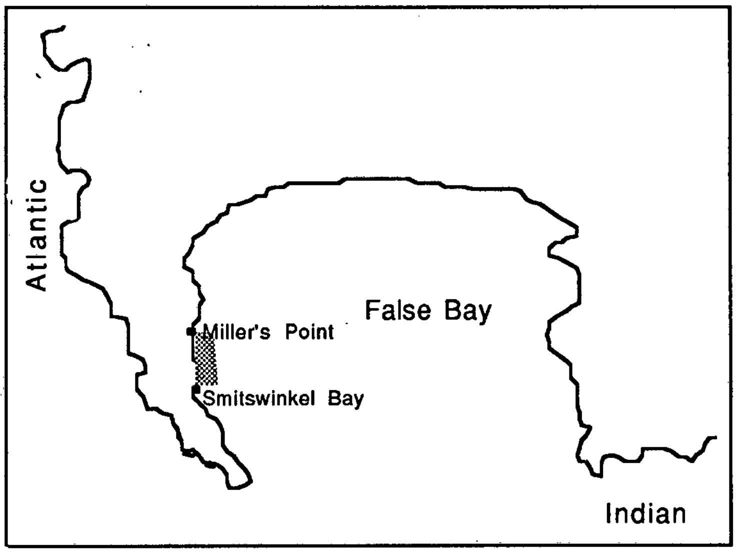
A census of the reef fish abundance and size structure was undertaken in the vicinity of the Castle Rocks marine reserve, False Bay (established during 1979) , and on similar reefs adjacent to the reserve, on which angling and spearfishing is allowed. The objective was to determine whether the populations within the reserve were different to those outside, in terms of species richness, abundance or size distribution.

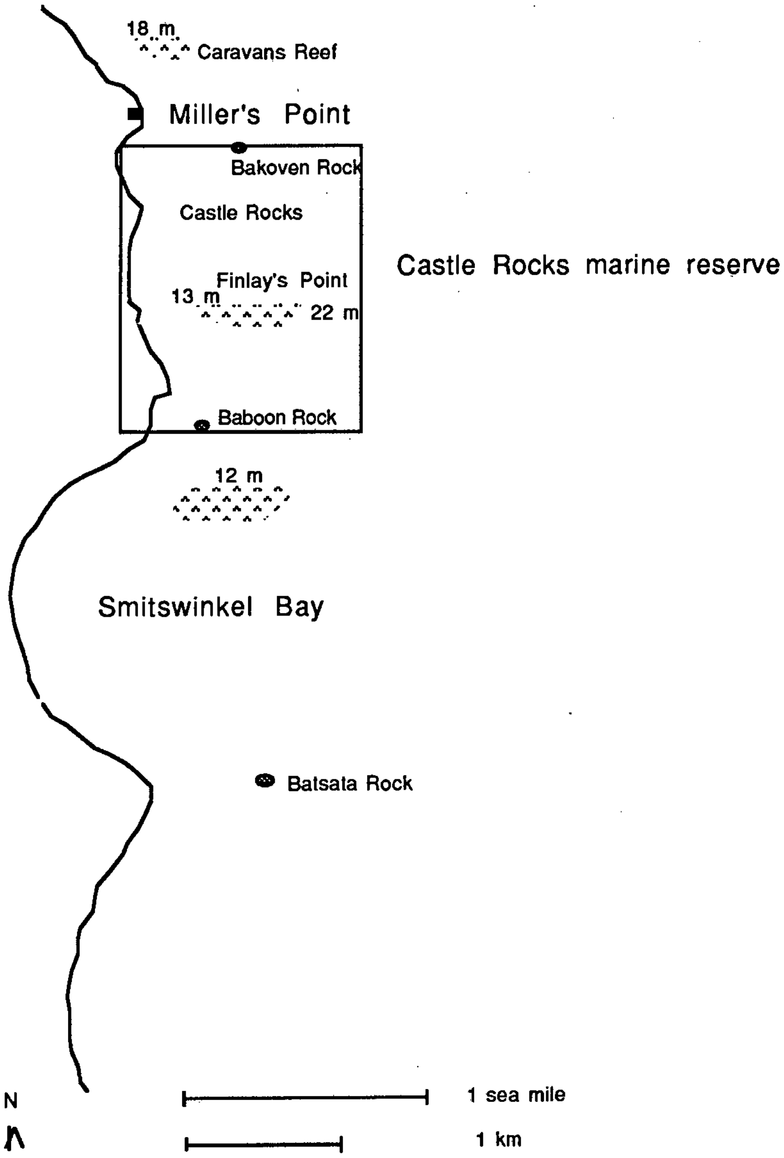
Study area and methods:

The Castle Rocks marine reserve (Fig. 5.1) was selected as the study site, as it has been in existence for long enough (10 years) to allow potential recovery in the fish populations, relative to those associated with adjacent unprotected reefs that are still subject to exploitation pressure. Two reefs were located within the reserve by echosounder: one at 22m depth and another at 13m. Land fixes were photographed, so that the same positions could be relocated during future censuses. By the same technique, one shallow reef was selected in the vicinity of Smitswinkel Bay (12m), adjacent to the west boundary of the reserve and a second at a depth of 18m in the vicinity of Miller's Point, adjacent to the eastern boundary of the reserve. The four sites were selected within close proximity of one another, so as to minimize variations in topography. All sites had a mixture of large granitic boulders, broken rock platform and some sand, covering a comparable depth range.

The census technique used was a version of the instantaneous

Figure 5.1: Map of Castle Rocks marine reserve and adjacent reefs





point count (Thresher & Gunn 1986), modified by Penney (SFRI). On relocating the selected site by echosounder and alignment of fixes on land, a weighted buoy was cast overboard. Two divers then positioned themselves 10m apart, one at each end of a 10m distance line, which was attached by its centre to the buoy line. After a short period the divers commenced instantaneous point counts in a water column (dimensions: r = 5m, h = 5m) surrounding each one of them. The divers were thus counting fish in adjacent columns of water. Each count was done by noting all fish species, and their numbers and sizes as the diver rotated through 360 in the water column (lasting less than one minute). The counts were repeated ten times by each of the divers for each of the water columns. All sites were dived on during one day, so that water conditions (temperature and visibility) would be the same for all sites during a particular census. The entire sampling series was carried out twice, once in February 1988 and again in October 1988.

Results:

The water conditions during the two census periods were as follows: In February the visibility was 5m at all sites, while there was a 2 ^{O}C temperature gradient between the shallow (14 ^{O}C) and deep (12 ^{O}C) reefs. During October conditions were the same at all sites with 9m visibility and a water temperature of 14 ^{O}C.

Results obtained from the two fish censuses done during 1988 are tabulated. Tables 5.1 and 5.2 show the abundance of fish on shallow and deep reefs, both within and outside the marine reserve:

Hottentot (Pachymetopon grande)

TABLE 5.1 : Mean fish densities were obtained during February 1988 from 15 - 20 Instantaneous point counts of all fish present in a volume of water with dimensions of 5x5x5 m^3 within a period of 10 minutes, where two divers counted adjacent water columns. All above point counts were obtained on the same day, so that water conditions such as visibility and temperature were similar for all sites. Species sighted, but not listed here include: hagfish, 3 species of dogfish, Cheilodactylis and pufferfish.

Fish species nr/m3	Reserve shallow mean	std	%V	Reserve deep mean	std	%V	Non-reserve shallow mean	std	%V	Non-reserve deep mean	std	%V
Hottentot	.004	.008	200	.204	.072	35	.038	.014	37	.041	.029	71
Roman	.002	.002	100	.011	.023	209	.009	.007	78	.003	.004	133
Red Stump.	.019	.028	47	.001	.004	400	0	0	-	0	0	-
Butterfish	0	0	-	<.001	<.001	-	0	0	-	<.001	<.001	-
Fransmadam	.004	.013	325	0	0	-	0	0	-	0	0	-
BankSteenbras	.001	.001	-	0	0	-	0	0	-	0	0	-
Zebra	<.001	<.001	-	0	0	-	0	0	-	0	0	-
Steentjie	<.001	<.001	-	0	0	-	0	0	-	.002	.005	250
BlueHottentot	0	0	-	0	0	-	.001	.002	200	0	0	-
Carpenter	0	0	-	0	0	-	0	0	-	<.001	<.001	-
John Brown	0	0	-	0	0	-	0	0	-	0	0	-
Milkfish	0	0	-	0	0	-	0	0	-	0	0	-
TOTAL	.032	.054	169	.217	100	46	.048	.023	48	.048	.040	83
TOTAL NO. SP.		10			5			4			7	

TABLE 5.2 : Mean fish densities were obtained during October 1988 from 20 Instantaneous point counts of all fish present in a volume of water with dimensions of 5x5x5 m^3 within a period of 10 minutes, where two divers counted adjacent water columns. All above point counts were obtained on the same day, so that water conditions such as visibility and temperature were similar for all sites. Species sighted, but not listed here include: 3 species of dogfish and Cheilodactylis.

Fish species	Reserve						Non-reserve					
	shallow			deep			shallow			deep		
nr/m3	mean	std	%V	mean	std	%V	mean	std	%V	mean	std	%V
Hottentot	.006	.010	167	.063	.034	54	.046	.031	67	.028	.026	93
Roman	.006	.004	67	.015	.007	47	.009	.004	44	.015	.006	40
Red Stump.	.015	.009	60	.002	.002	100	0	0	-	0	0	-
Butterfish	<.001	-	-	.0	0	-	001	.002	200	0	0	-
Fransmadam	0	0	-	.003	.011	-	0	0	-	.001	.003	300
BankSteenbras	.001	-	<.001	-	-	0	0	-	0	0	-	-
Zebra	0	0	-	0	0	-	0	0	-	0	0	-
Steentjie	0	0	-	0	0	-	0	0	-	0	0	-
BlueHottentot	0	0	-	.002	.004	-	<.001	.002	-	0	0	-
Carpenter	0	0	-	0	0	-	0	0	-	0	0	-
John Brown	0	0	-	<.001	-	-	0	0	-	<.001	-	-
Milkfish	0	0	-	<.001	-	-	.002	.003	-	<.001	-	-
TOTAL	.029	023	79	.088	.058	66	.059	.042	71	046	035	76
TOTAL NO. SP.		7			11			7			7	

The numbers in both February and October censuses were highly significantly different between the deep and shallow reefs (X^2 = 53.19, df = 17, p = 10^{-4} in February, and X^2 = 122.36, df = 19, p = 10^{-4} in October), being more abundant on the deep reef. This species also had highly significant differences in their abundances inside and outside the reserve during both census periods (X^2 = 123.66, df = 17, p = 10^{-4} in February and X^2 = 76.83, df = 19, p = 10^{-4} in October), being more abundant inside the reserve than outside.

Roman (Chrysoblephus laticeps)

This species showed no significant difference in numbers on deep and shallow reefs, during either of the census periods. Nor was there any significant difference in their abundances inside or outside of the reserve during the October census, however, the significance could not be tested for the February data set, as the numbers of Roman were too low to apply the Chi - square test to this data set.

Red Stumpnose (Chrysoblephus gibbiceps)

This species was only present within the reserve, on both shallow and deep reefs during the February and October censuses, so that it was not possible to test for the significance of differences in abundances of this species.

Bank Steenbras (Palunolepis grandis) and Fransmadam (Boopsoidea inornata) were more abundant within the reserve than without, during both February and October censuses, unfortunately, due to the low numbers the significance of this statement cannot be tested statistically. Blue Hottentot (Pachymetopon aeneum) was less abundant on the shallow reef in the reserve, during both census periods, but more abundant on the deep reef in the reserve, during October 1988, than outside the marine reserve, but again these fish were not present in high enough numbers to verify this statement statistically.

Figures 5.1a and b present the size frequency distributions for all sites, of the most prevalent three species of both censuses: Hottentot (Pachymetopon grande), Roman (Chrysoblephus laticeps) and Red Stumpnose (Chrysoblephus gibbiceps). Significant differences in the size frequency distributions of these three species, at all sites censused were as follows:

Hottentot

The shallow reef population outside of the marine reserve had a significantly larger size distribution than inside the reserve during the February census (Kolmogorov-Smirnof statistic = 0.63, $p = 9.63E^{-7}$). The deep reef population within the reserve had a larger size frequency distribution than the shallow reef population within the reserve during the February census (Kolmogorov-Smirnov statistic = 0.48, $p = 1.79E^{-4}$). None of the other Hottentot populations showed any significant difference in their size frequency distributions ($p = 0$ or $p > 0.05$).

Roman

Significantly different size frequency distributions ocurred in almost all instances:

February census - .

- on the deep reef inside the reserve the Roman population had a larger size frequency distribution than the population on the deep reef outside the reserve (Kolmogorov-Smirnof statistic = 0.55, $p = 0.025$).

- on the shallow reef inside the reserve the population had a

Figure 5.1a: Size distribution of dominant fish present during February '88 on:

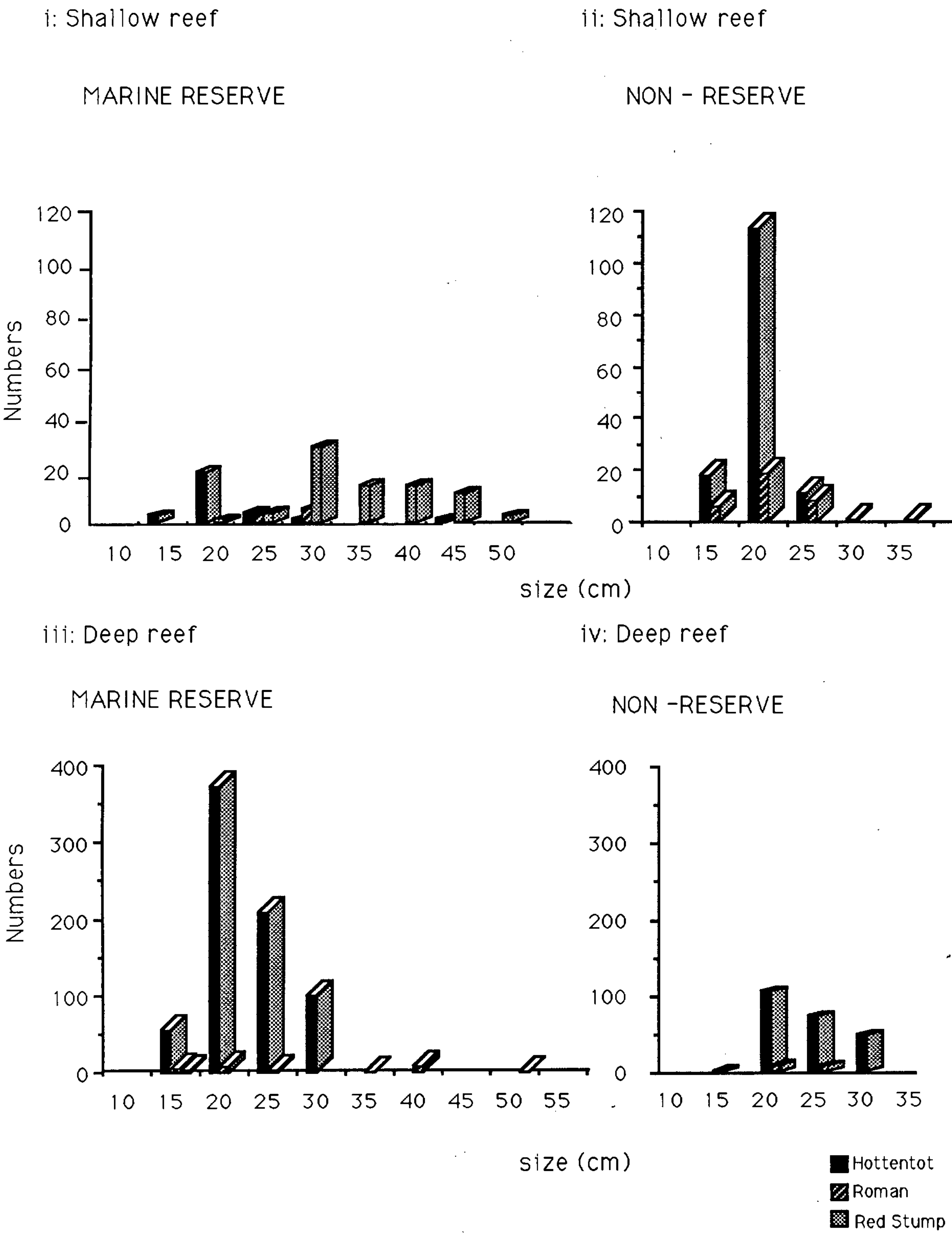
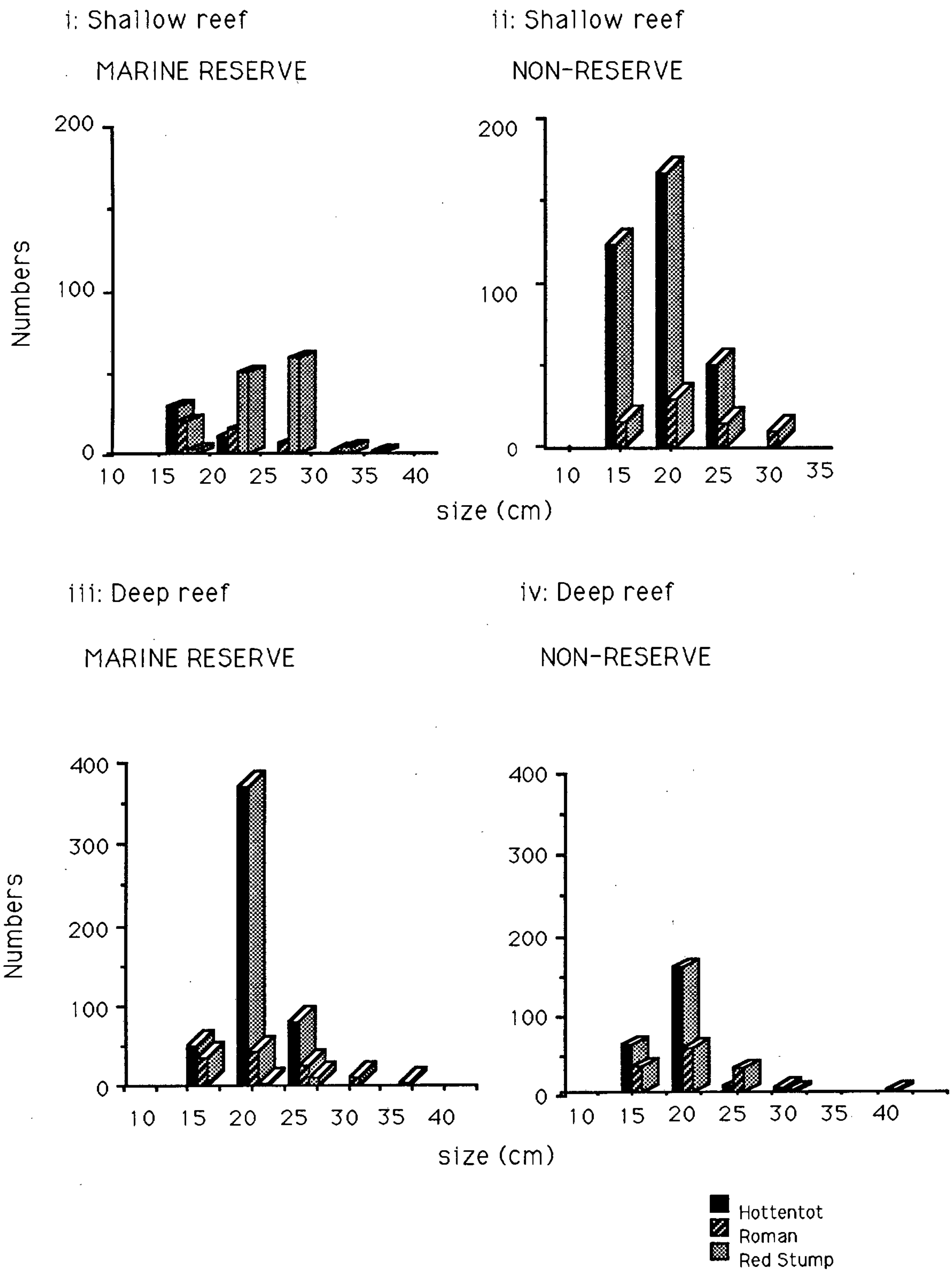


Figure 5.1b: Size distribution of dominant fish present during October '88 on:



smaller size frequency distribution than the shallow reef population outside the reserve (Kolmogorov-Smirnof statistic = 0.74, p = 7.01 E^{-3}).

- on the deep reef inside the reserve the size frequency distribution of the population was greater than on the shallow reef inside the reserve (Kolmogorov-Smirnof statistic = 0.64, p = 0.044).

October census -

- the same applies as for the February census with the following statistics: Kolmogorov-Smirnof statistic = 0.39, p = 5.24 E^{-8}.
- for the shallow reef populations inside and outside the reserve the same applies as for the February census, with the following statistics: Kolmogorov-Smirnof statistic = 0.56, p = 0.001.
- as during the February census there was a significant difference between the reserve populations on the deep and shallow reefs, with the following statistics: Kolmogorov-Smirnof statistic = 0.29, p = 8.3 E^{-3}.

Red Stumpnose

This species was consistently absent from the reefs outside the reserve, during both censuses, therefore size frequency distributions could only be calculated for the populations on the reefs within the reserve, with the following results:

During both censuses the shallow reef population had a greater size frequency distribution than the deep reef population (Kolmogorov-Smirnof statistic = 0.47, p = 0.039 during February and Kolmogorov-Smirnof statistic = 0.54, p = 0.001 during October).

Discussion:

It would be premature to draw definite conclusions from these preliminary surveys of reef fish assemblages inside and outside the Castle Rocks marine reserve for various reasons. Many more observations would need to be made in order to reduce the coefficient of variance (which ranges from 37 - 400%) for this data. Other visual census techniques should also be employed to supplement the instantaneous point counts, as there are advantages and disadvantages associated with the different techniques, eg. point counts are best suited for mobile species, while line transects are best suited for estimating sedentary species abundances (Buxton & Smale 1989). At best any visual census technique can only provide an index of relative abundance, eg. inside versus outside a marine reserve, not an absolute measure of population size. Although these limitations are inherent in visual census techniques, they are ideal for the evaluation of relative population differences between areas.

There are, however, two aspects that have been consistently noted during the census periods:

- the fish species richness appears to be greater within the Castle Rocks marine reserve, than on the adjacent reefs outside the reserve.
- Red Stumpnose were absent from the areas censused outside the Castle Rocks marine reserve.

These findings would seem to indicate that the marine reserve is an effective sanctuary for reef fish in False Bay, which may unfortunately change very soon, as a result of the presence of linefishermen in the reserve. The status of this reserve changed late in 1988, when it was declared open to Snoek fishing. Although the techniques used for catching Snoek (<u>Thyrsites atun</u>) should not result in the taking of reef fish, there is very little stopping these fishermen from catching reef fish, if they so wish. It is legal to be in the reserve now and to fish, so strict control is needed to monitor what is being caught.

Buxton and Smale (1989) found that C. laticeps and P. rupestris densities were significantly different between the exploited site at Cape Recife and the protected site at Tsitsikamma, the exploited site having far fewer fish per unit area. They also found that size frequency distributions of the species studied differed between sites - the exploited area having a smaller proportion of large fish and a smaller maximum size. They concluded from this study that marine reserves are an effective management option for the protection of species that are exploited. The preliminary findings of our study seem to support this notion.

Acknowledgements:
I would like to thank Mr. A. Penney for his expert advice and assistance with the undertaking of the censuses. Mr. P. Hanekom and Dr. R. Bally also deserve thanks for their assistance.

Chapter 6

The effects of experimental disturbance on communities associated with intertidal boulders on a sheltered shore

The effects of experimental disturbance on communities associated with intertidal boulders on a sheltered shore.

Abstract:

Boulders from a sheltered intertidal boulder field were subjected to artificial experimental disturbance of two types - over-turning or lifting and replacing. These manipulations were carried out at different frequencies, over a one-year period. The communities on the boulders were monitored to detect resultant changes in species abundance and diversity. Communities living on boulders lifted and replaced were affected negatively, just as were those on boulders that were turned over and left upside down. Increasing frequencies of disturbance, from twice a year to twelve times a year, resulted in progressively greater declines in species diversity within the boulder communities. The sponge Hymeniacedon perlevis, the green alga Ulva, the false limpet Siphonaria aspera, and the limpet Helcion pectunculus were amongst the affected species.

It is concluded that boulder communities are adversely affected by the over-turning. This effect is proportional to the frequency of disturbance, but occurs regardless of whether the boulders are replaced or left over-turned.

Introduction:

There is no single simple explanation for the patterns of species diversity in communities. The species - area relationship, which describes a positive relationship between the number of species and the size of an area, is one well- documented phenomenon

(Connor & McCoy, 1979) and is accounted for by three main hypotheses: passive sampling / random placement (Connor & McCoy, 1979); habitat diversity (Connor & McCoy, 1979) and the equilibrium theory of island biogeography, (MacArthur & Wilson, 1967).

Another, fourth hypothesis, the intermediate disturbance hypothesis, is unrelated to the area of samples, but states that the greatest diversity occurs at intermediate levels of disturbance (Connell, 1978).

In intertidal marine environments natural disturbances include: wave action, sand scour, grazer or predator pressure, starvation, floating logs, rock movement, uplifting and earthquakes, amongst others (Dayton 1971, Connell 1978, Paine & Levin 1981, Taylor & Littler 1982, Castilla 1988). Each of these factors results in the creation of space within a community.

For intertidal boulder communities disturbance is often linked to wave action, which cause boulders to be over-turned or cast about thus impacting even on stable rocks, tearing organisms off the rocks (Dayton 1971, Paine & Levin 1981) or damaging them by sand scouring (Taylor & Littler, 1982).

Such disturbances kill organisms and create free space (McGuinness 1987b). In so doing succession is interrupted and local species diversity is influenced. Small boulders are over-turned more frequently than large ones, so that a patchwork of successional stages is created in the boulder field, with intermediately disturbed rocks having the greatest diversity (Sousa 1979).

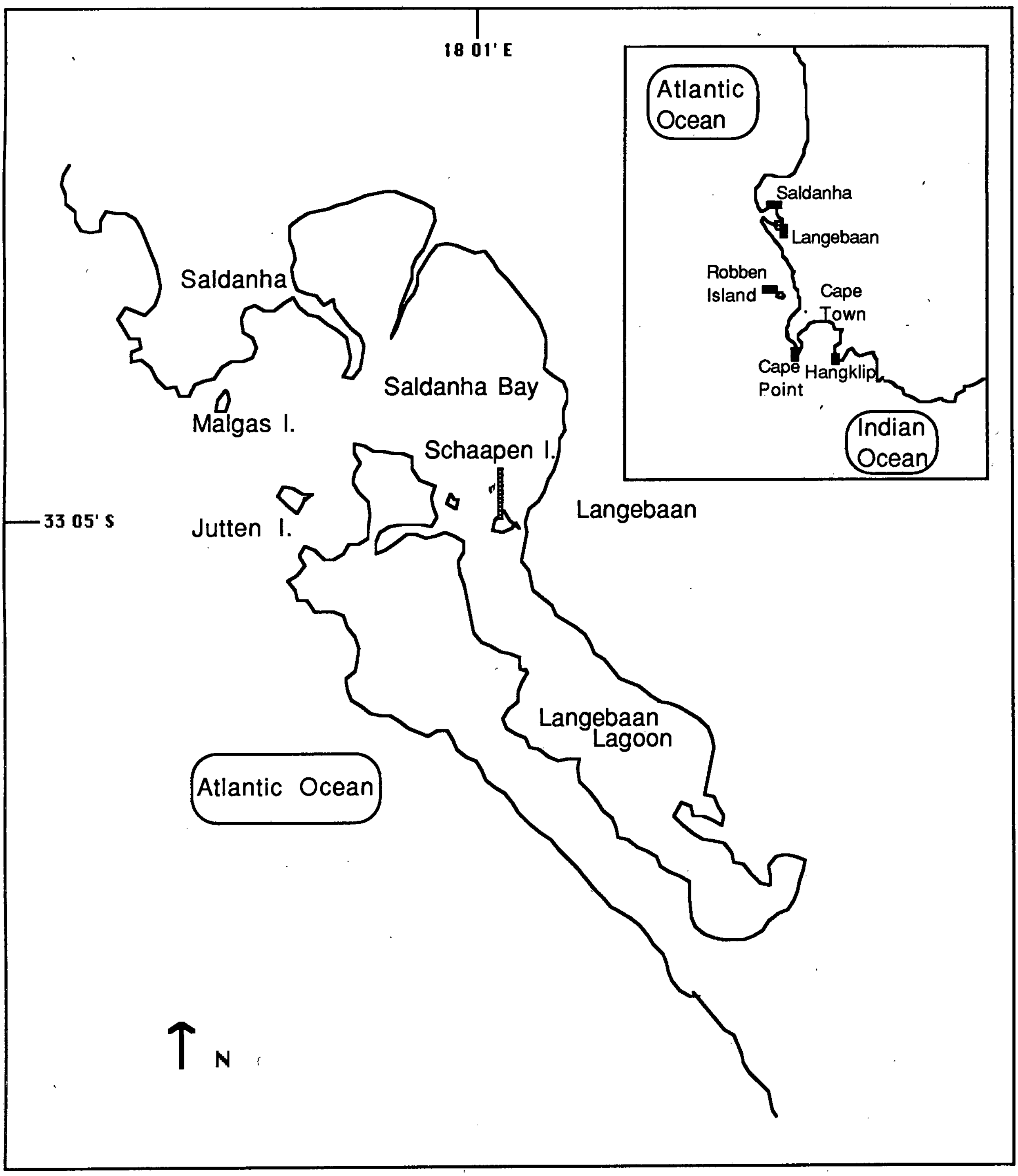
Many different forms of human activities also affect intertidal and shallow-water boulder communities. These include bait collection, food gathering or simply inquisitive observation of life underneath boulders. Whether in pursuit of prey or knowledge, the community associated with a boulder that is overturned by man, is disrupted. It is a frequently stated belief that the extent of the damage to such communities can be minimized by ensuring that boulders are replaced in their original positions, after being lifted and such a recommendation is incorporated in many seashore guides.

The following account documents the response of boulder communities to physical disturbance in the form of overturning at different frequencies. The effects of leaving boulders overturned until the next period of manipulation, are compared with the effects of immediately replacing them in their original orientation and position, after they are overturned.

Study site and methods:

The study site, Schaapen Island (Fig 6.1) is a small, uninhabited rocky islet at the entrance to Langebaan Lagoon on the West coast of South Africa. It has a sheltered leeward boulder shore, which was selected as the study site for two reasons. It is situated in a conservation area and has restricted access, as only permit holders may visit the island. Being a sheltered shore the level of natural disturbance due to wave action is also minimal, any wave action being absorbed by the open coast headland before reaching the island. There are no seasonal differences in the levels of disturbance, as the Southeast wind is blocked in summer by the southern headland and the Northwest wind is blocked in

Figure 6.1: Map of the Southwestern Cape indicating the study area, Schaapen Island, relative to Saldanha Bay and the rest of the West Coast of South Africa.



winter by the northern headland of the Bay.

Boulders were selected along the lowshore (0.2 - 0.3 m above MLW) on the leeward side of the island. Treatments were of two kinds - boulders were either rolled over and left over-turned or they were replaced after being over-turned. Experimental boulders had a mean size of 0.34 m^2 (S.D. 0.1 m^2). These disturbances were executed at various frequencies: annually, biannually, quarterly or monthly for each set of five boulder replicates. At several visits three or four random control boulders were assessed for community composition. Boulders were labelled on both the upper and lower surfaces using Prattley's puttey and plastic, coded tabs. Five controls were also labelled to be monitored at the end of the experiment.

At each visit the communities associated with the relevant boulders were assessed: macro-organisms living both on the upper and lower rock surfaces were counted, or percentage cover assessed in the case of encrusting or colonial forms. After one year (March 1987- May 1988) the experiment was terminated and boulder surface areas were roughly estimated by measuring the maximum horizontal and vertical circumferences of the labelled boulders.

Untransformed data were analysed using complementary classification and multi-dimensional scaling (MDS-ordination) techniques. Information statistics, which distinguish species from one group of boulders from those of another group, were used to find indicator species. Although this test does not meet rigorous statistical criteria , it does provide useful information in conjunction with classification and ordination analyses of the data (Field et al. 1982).

Results:

Typically the communities on the upper and lower surfaces of boulders differed. The upper surfaces were characterised mainly by the opportunistic alga Ulva and the barnacles Tetraclita serrata and Octomeris angulosa. Siphonaria aspera were also observed. The bottom surfaces were characterised by various gastropods: Oxystele tigrina, Oxystele variegata , Burnupena cincta , Patella granatina, P. oculus, Acanthochiton garnoti and Chiton tulipa . Actinia equina, Helcion pectunculus and encrusting organisms such as bryozoans and the sponge Hymeniacedon perlevis also occurred there.

The number of species and thus species diversity were reduced on all boulders that were disturbed more frequently than once a year. This occured regardless of the type of treatment, ie. boulders that were over-turned and left over-turned (Fig 6.2a) were affected as much as those that were over-turned and replaced (Fig 6.2b). Thus the number of species on control boulders increased by 7% from 14 to 15 over the one year period of the experiment. Annually disturbed boulders had an increase in species number of 8% in the case of boulders that were left over-turned, or no change associated with boulders that were replaced after over-turning. Biannually disturbed boulders showed a decrease in species number of 10 - 12 % for the two types of treatment. Quarterly disturbed boulders had a reduction in species diversity of 62% for boulders left over-turned and 10% for boulders replaced after overturning. Boulders that were disturbed monthly over a period of one year showed a decrease in number of species of 25% for boulders that were not replaced after manipulation and 14% for boulders that were replaced after

Figure 6.2a: Temporary changes in numbers of species found on boulders that were rolled over and left overturned at different intervals, as indicated, over a period of one year. (Bars indicate +/- one S.D.)

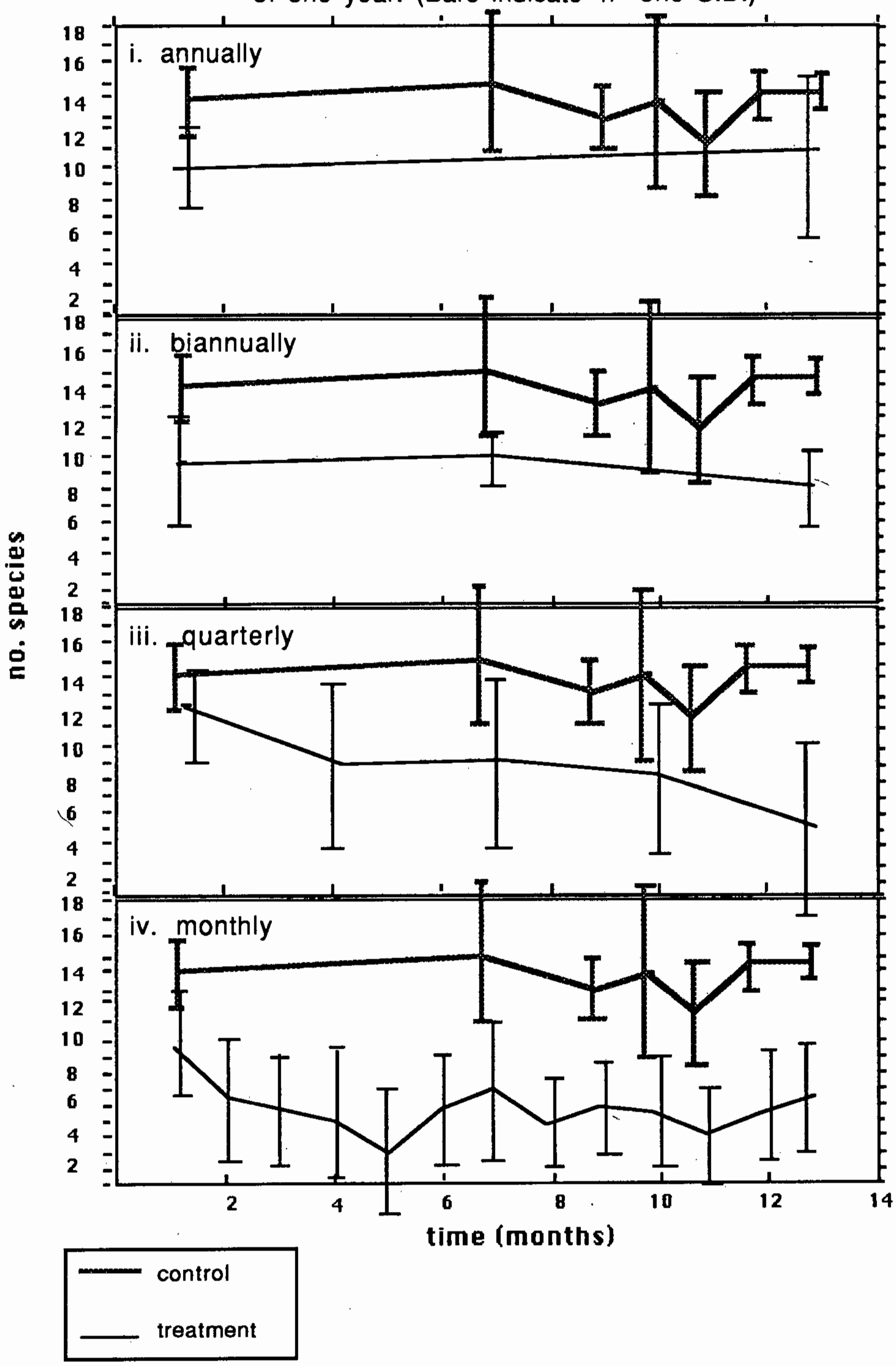
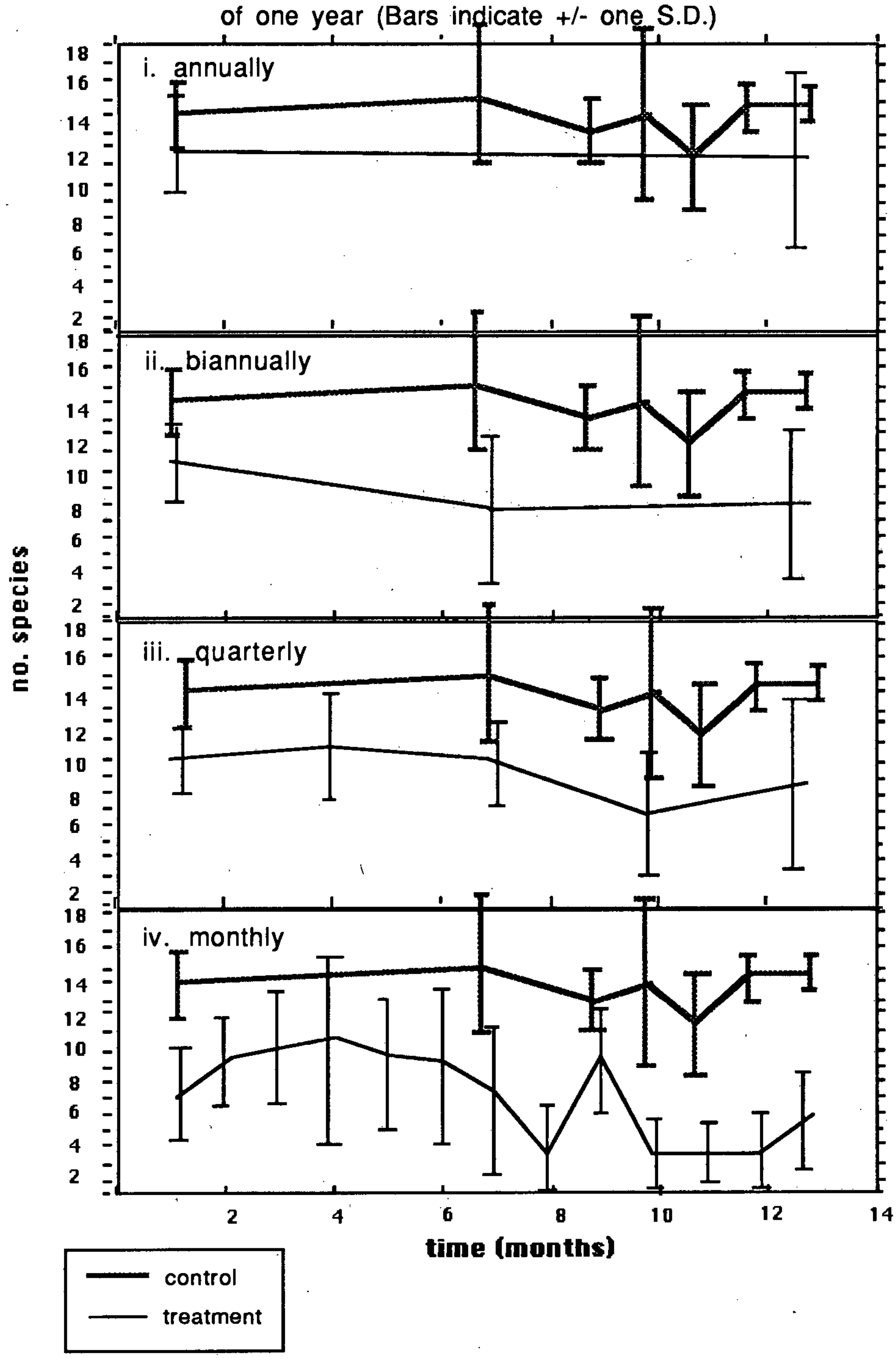


Figure 6.2b: Temporal changes in number of species found on boulders that were rolled over and replaced at different intervals, as indicated, over a period of one year (Bars indicate +/- one S.D.)



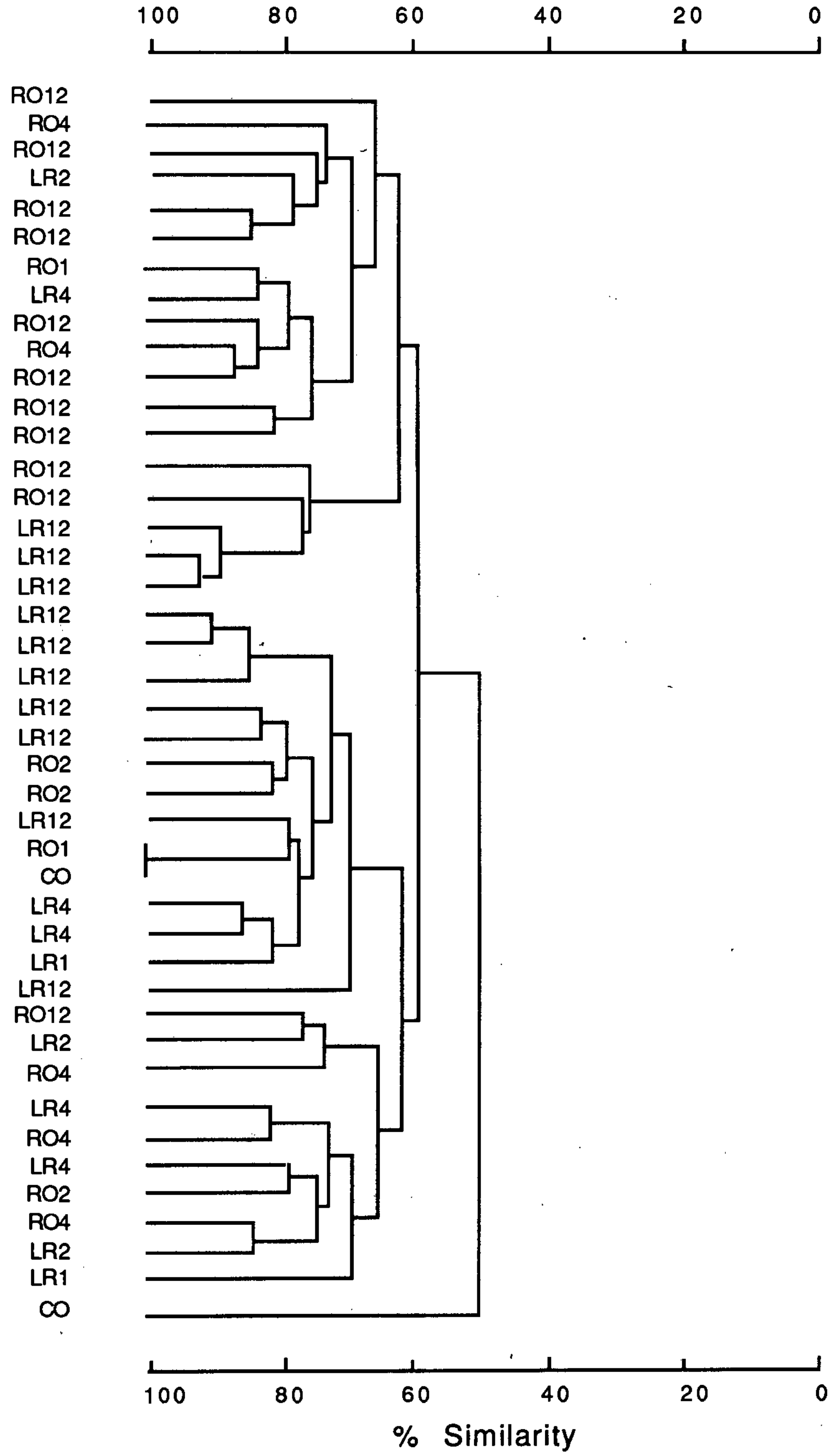
each manipulation. These comparisons were made using mean number of species for each set of 5 replicate boulders, as the boulders were of variable size, it was assumed that the use of mean values would compensate for variability in individual boulder sizes.

Classification analysis of replicate sets of five boulders each that were subjected to different disturbance regimes at different frequencies using the Bray - Curtis measure of similarity and group - average sorting showed some pattern of grouping:
The main groups consist mainly of rocks that were overturned monthly (RO12), another related group of rocks that were rolled and replaced monthly (LR12), and the remainder that were rolled less frequently. The results show considerable variability among replicates and the pattern is by no means clear.

Less frequently disturbed boulders ie. biannually or annually over-turned boulders showed no distinct grouping (Fig 6.3). This lack of grouping is to be expected, as the infrequently disturbed boulders maintained communities similar to those present at the beginning of the manipulation, which were highly variable between replicates. More frequently disturbed boulders, however, showed a reduction in species diversity (see Fig 6.2). Comparable results were recorded by Hockey and Bosman (1986) who found in their study along the Transkei coast that disturbance through selective predation leads to community convergence towards a common state.

Multi-dimensional scaling gives essentially the same picture as the dendrogram (Fig 6.4). Annually disturbed and control boulders do not form distinct clusters. Biannually disturbed boulders do, however, form clusters- those that were over-turned and replaced separating from those that were left over-turned. Quarterly disturbed boulders separate fairly well into two groups

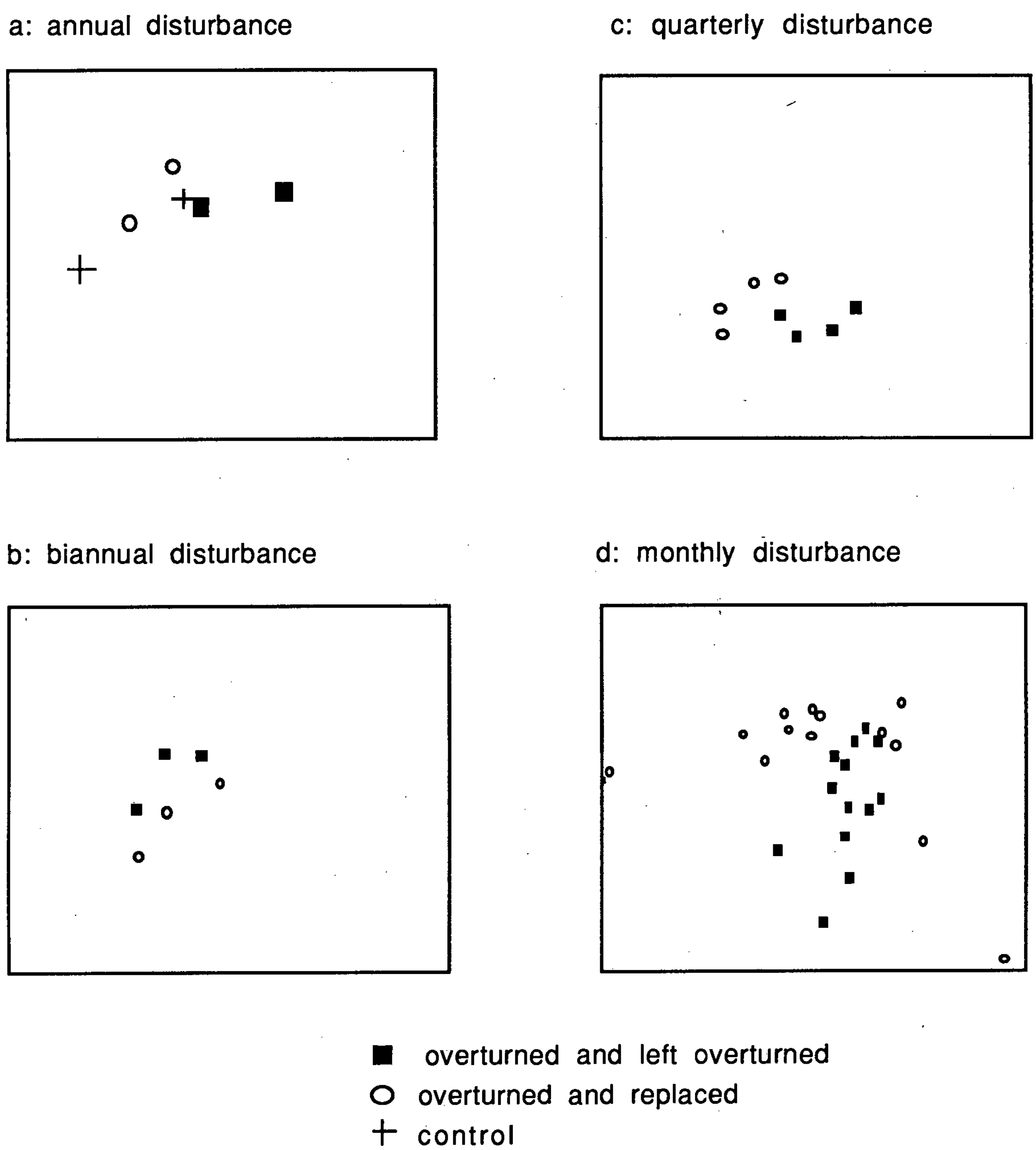
Figure 6.3: Dendrogram of similarity analysis based on mean numbers of species present on replicate sets of boulders, subjected to different disturbance regimes and frequencies



RO - Boulders that were overturned and left in that position
LR - Boulders that were overturned and replaced immediately
CO - Control boulders

- Numeric code denotes frequency of disturbance: 12 = monthly, 4 = quarterly, 2 = biannually, 1 = annually

Figure 6.4: Multi-dimensional scaling ordination analysis on species composition of replicate sets of boulders, subjected to different disturbance regimes. Each diagram represents data which has been isolated from a single cluster diagram, i.o.t. simplify visualisation



on the basis of the two types of treatment received, as do monthly disturbed boulders, with some outlying points.

Changes in the densities of the most common species on the most frequently disturbed boulders are shown in Table 6.1: Mobile species that showed a reduction in numbers at the end of the experiment were Chiton tulipa, Acanthochiton garnoti, Patella granularis & Patella oculus , whereas the winkles Oxystele variegata, O. tigrina, the whelks Burnupena cincta & Nucella dubia, the asteroid Patiriella exigua and the limpet Helcion pectunculus showed variable responses. Sessile species that were reduced in numbers by the treatment include the barnacle Tetraclita serrata, the anemone Actinia equina and the sponge Hymeniacedon perlevis.

Indicator species could be identified using information statistics. There was no obvious trend in the distribution of indicator species on the basis of treatment regime. The frequency of disturbance did, however, affect the distribution of indicator species. When comparing the boulder communities that were disturbed at a high to medium frequency (monthly to quarterly) and those that were disturbed at a medium to low frequency biannually to annually), two groups of species were consistently identified (with a significance of $p < 0.05$) The chitons Acanthochiton & Chiton tulipa; the winkle O.tigrina; the whelk Nucella and the patellids were always more abundant on the less frequently disturbed boulders. Conversely the winkle O.variegata was less abundant on the less frequently disturbed boulders than on those disturbed more frequently (Table 6.2a). The increase in O.variegata may simply be a result of the decrease in O.tigrina on frequently disturbed boulders, as abundance of these two similar gastropods was reciprocal to each other.

Discussion:

Complex changes in the community structure of macro-organisms associated with both the tops and undersides of boulders were found in this study. Physical disturbance, regardless of its frequency, was important, but not for all species. This finding is not in agreement with McGuinness (1987 a), who suggested that physical disturbance is only important for sessile organisms living on the undersides of boulders, and that only frequent disturbance is important. It would not be wise to try to justify such differences, as the experimental procedures used were fundamentally different: this study was done on a very sheltered shore and any physical disturbance to the boulder communities was brought about by our manipulations, whereas McGuinness studied a wave exposed shore, where physical disturbance of the boulders was brought about by wave action and not human manipulation, control boulders being fixed to the surface, so that they could not be over-turned by waves.

Ideally the experiment should not have been terminated after only one year of boulder manipulation, so that any underlying seasonal effects could have been filtered out of the data and successional events followed. Unfortunately, it was not possible to do this.

A major factor to be considered in this study is the relative lack of algal cover in the boulder field on the leeward shore of Schaapen Island. This may be an important factor, as algae are often primary space-occupying species that have repeatedly been found to be most affected by physical disturbances. Such disturbance of algae results in the clearing of space, overriding other effects such as competition and grazing (Sousa 1979a, Littler & Littler 1981). Ulva was the only well represented macro-alga on our study shore, although it was restricted to the rock platform and rarely present to any great extent on the tops or undersides of boulders. This in itself is fairly unexpected. Most South African shores and, indeed, other islands in Saldanha Bay - Marcus, Jutten and Malgas have dense algal mats intertidally (Bosman & Hockey 1986). McGuinness & Underwood (1986) found that the boulder thickness (vertical dimension) affects the abundance of foliose macroalgae, as these rocks experience increased emersion periods. This may explain the relative lack of macroalgae on boulders in the study area, as the environment experienced by these communities is effectively harsher, being high enough as to be out of the normal algal zone on this sheltered shore.

Ulva, the one species of macroalgae that was represented in this experiment, was in fact affected both by the type of treatment and by the frequency of physical disturbance. Other sessile space-occupying species that were reduced in abundance due to boulder manipulation were Tetraclita serrata and Hymeniacedon perlevis. Octomeris angulosa on the other hand seemed to increase in abundance in both types of treatment: this seems to be due to recruitment, as abundance of Octomeris angulosa increased on control boulders as well.

The variability in response of mobile species to boulder disturbance cannot be satisfactorily explained by this study. It is assumed however, that mobile species can recolonize from other areas to disturbed boulders at any time after feeding excursions, so that a trend in these species numbers cannot be expected. Branch (1985) argued that mobile species are more resilient to disturbance, as they can recolonize either as adults or as larvae, whereas sessile species must rely on planktonic larvae for recolonization of boulders from which they have been eliminated by disturbance.

The classification of boulder sets into three main groups indicates that there is a difference in the effect of different treatment regimes on boulder communities, although all communities are negatively affected by disturbance more frequent than once a year. Boulders that are most frequently disturbed by over-turning and being left over-turned form one group. The second group of boulders, which were also most frequently disturbed, but replaced after being over-turned. The third group comprises intermediately disturbed boulders from both groups.

The multi - dimensional scaling ordination of boulder treatments reinforces the classification results, indicating that there is a difference in boulder communities on the basis of the frequency as well as the type of disturbance experienced, although groups seem to be based on the different types of treatment with some overlap within such groups that have experienced the same frequency of disturbance.

Our overall conclusion is that disturbance does have an impact on boulder communities, which is not neccessarily reduced if boulders are replaced once they have been overturned.

The conservation implications of these findings for human activities are : The communities of sheltered boulder shores that are frequently and easily accessed by the public are unwittingly damaged, be it by casual inquisitive students of nature that are merely observing or by collectors of shore animals. This damage will be more marked if there are few boulders, as the frequency of disturbance will be very high for each boulder. However, if a boulder shore is densely packed with boulders, or is not easily accessible to the public, then the level of disturbance should be negligible, due to the low frequency of over-turning of any individual boulder. However, on exposed boulder shores the impact of such human activity may pale into insignificance, as wave action causes frequent boulder diruptions. Boulders on such exposed shores have a markedly reduced total biomass, due to frequent disturbance of the boulders by the natural forces of the sea (McQuaid & Branch 1985). Management policy makers should take cognizance of the implications and legislate accordingly.

Acknowledgements:
This work was done in collaboration with Mr. C. du Plessis, but the analysis and write - up of the chapter was done by myself.Thanks are due to the Coastal Parks section of Marine Affairs, Department of Environment Affairs, for permitting us to perform the experiment on Schaapen Island and to all those that assisted us in our journeys to the island. Thanks to Mark Gibbons for his helpful advice and to Colleen Moloney for her assistance during the similarity analysis of the data. We gratefully acknowledge funding for this research by the Council for Scientific and Industrial Research and the Sea Fisheries Research Institute.

Chapter 7

Collection of mussel worms (Pseudonereis variegata) for bait - a legislative anachronism

(Published in South African Journal of Marine Science 8 (in press))

Collection of mussel worms (Pseudonereis variegata) for bait - a legislative anachronism.

Abstract:

This study determines the extent of damage caused to mussel and Gunnarea capensis beds by the collection of Pseudonereis variegata for use as bait. Between 0,4m^2 and 5,0m^2 of mussel bed and 0,7m^2 Gunnarea reef is destroyed in the collection of the legal limit of 20 baitworms. This has implications for ecological succession and is at variance with legislative restrictions governing the collection of mussels.

Introduction:

Most rocky intertidal invertebrates exploited as food or bait are epibenthic primary space occupiers, eg. mussels and limpets (Hockey & Bosman 1986). An exception to this is the mussel worm (Pseudonereis variegata), which is an interstitial species occuring within beds of mussels, Gunnarea and barnacles. The primary biological matrix (mussels / Gunnarea) therefore is damaged during the collection of mussel worms. Fishermen use flat bladed implements (legally no wider than 3,8cm) to hack away and scrape off mussels or tubeworms in clusters, so as to expose large mussel worms resident in the beds. These worms are then gathered for use as bait.

The aim of this study was to determine the area of primary matrix which is destroyed in the collection of the legal bag limit of mussel worms and to examine these findings in the light of existing legislation and possible ecological consequences.

Five replicate samples of $400cm^2$ each were taken from two different sites occupied by each of the four mussel species that occur in the South Western Cape (Fig. 7.1), ie. Perna perna, Mytilus galloprovincialis, Choromytilus meridionalis , and Aulacomya ater and from two sites occupied by tube worms Gunnarea capensis. For each sample whole wet biomass of mussels and tubeworms (inclusive of tubes) were determined, as were number of mussels and the biomass, total numbers and number of "baitworthy" (>10cm length) worms (Pseudonereis spp.).

Extrapolations from these data were made to establish the number of mussels and area of mussel bed or tubeworm reef destroyed in the collection of 20 baitworthy worms (Table 7.1).

Between $0,4m^2$ and $5,0m^2$ of mussel bed (ie. 2 600 - 60 000 mussels) and $0,7m^2$ Gunnarea reef need to be dislodged in order to collect 20 bait worms, depending on the bed thickness and mussel species involved. Notably Choromytilus beds have an extremely low Pseudonereis population, if any at all, which is probably due to the high sediment loads associated with the mussel species. Aulacomya beds are impoverished as well, having less than 1% of the entire worm population of bait size which can be ascribed to the shallow depth of bed of this mussel species.

Dislodged mussels will only open and extend the foot for reattachment if they are in still water eg. a rockpool (C.L.Griffiths, pers.comm.), so that the vast majority of dislodged mussels will either be cast up on the driftline and die or be washed into gullies, where they often fall prey to anemones (Branch & Griffiths 1988). The Gunnarea reefs will similarly suffer severe damage as many worms are chopped in half

Figure 7.1: Map of South Western Cape indicating collection sites, including those of Davies (1984)

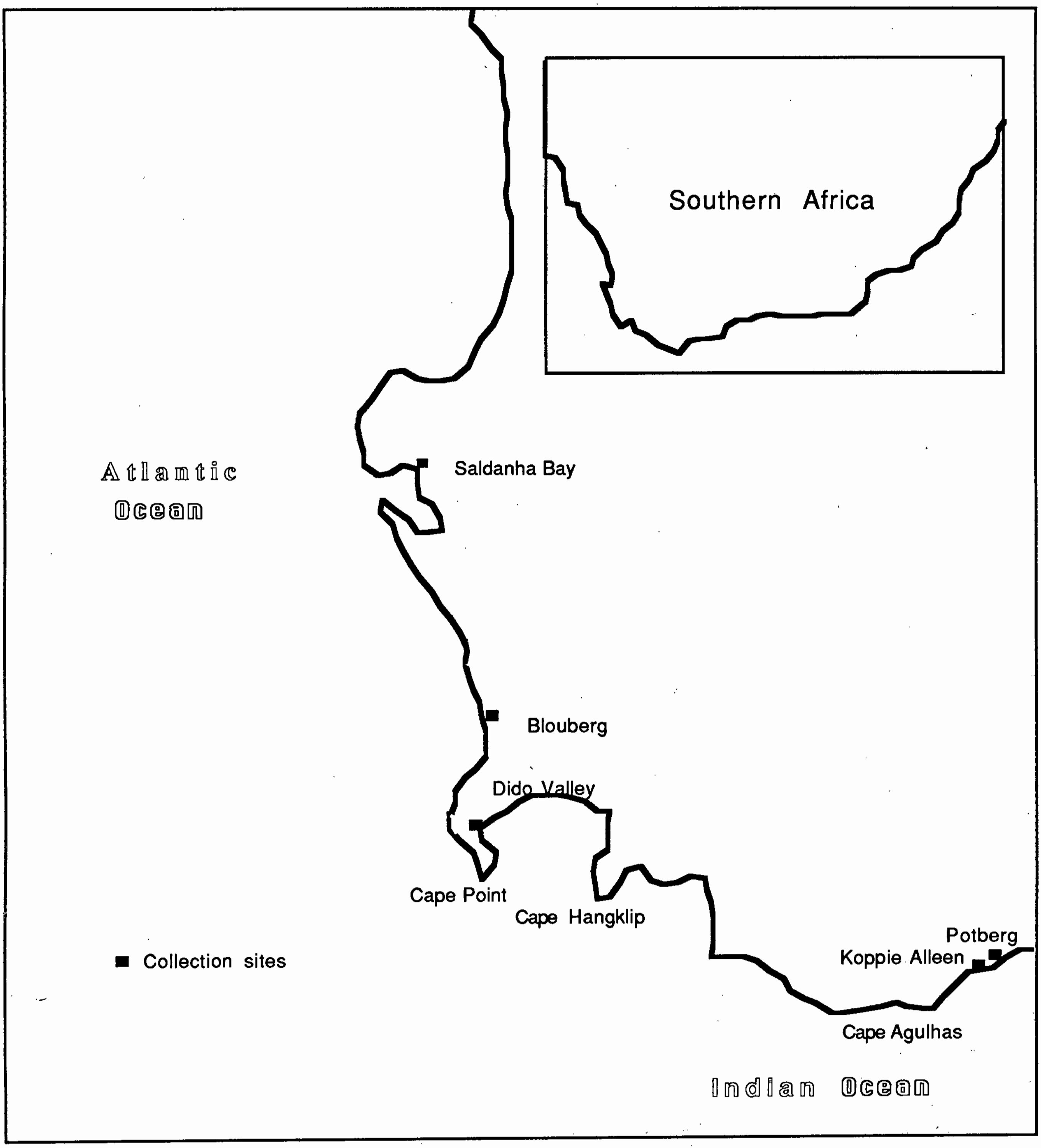


Table 7.1: Characteristics of mussel and reef worm beds and the mussel worm populations associated with them from various regions in the South Western Cape.

SPECIES	SITE	N	MEAN(mm) DEPTH	MEAN NOS. MUSSELS m^{-2}		MEAN (g) BIOMASS		MEAN TOTAL WORMS m^{-2}		MEAN BAIT WORMS m^{-2}		M^{-2} MUSSELS/ 20 BAITWORMS		NO. MUSSELS/ 20 BAITWORMS	
CHOROMYTILUS MERIDIONALIS	BLOUBERG	5	50	3905	(1936)	22735	(6325)	-	-	-	-	-	-	-	-
CHOROMYTILUS MERIDIONALIS	KOEBERG	5	10	800	(121)	39065	(8995)	10	(14)	-	-	-	-	-	-
MYTILUS GALLOPROVINCIALIS	BLOUBERG	5	100	7595	(1707)	36895	(5010)	590	(387)	35	(33,5)	0,5	(0,2)	2603	(958)
MYTILUS GALLOPROVINCIALIS	SALDANHA BAY	16	47	21018	(17377)	37541	(19874)	192	(178)	4,75	(3,41)	4	(2)	59885	(48012)
PERNA PERNA	DIDO VALLEY	5	50	5960	(1008)	44750	(19596)	845	(239)	50	(25)	0,5	(0,25)	3037	(1747)
PERNA PERNA *	KOPPIE ALLEEN	6	?	4655	(4402)	?	?	751	(92)	50	(13)	0,4	(?)	1862	(1760)
PERNA PERNA *	POTBERG	5	?	2425	(2074)	?	?	392	(251)	8	(1)	2,5	(?)	6063	(5185)
AULACOMYA ATER	BLOUBERG	5	20	3592	(2409)	27225	(8946)	735	(231)	-	-	-	-	-	-
AULACOMYA ATER	SALDANHA BAY	8	28	3410	(1854)	16071	(8781)	175	(153)	1,63	(2,33)	5	(1,5)	18937	(7266)
MEAN - ALL MUSSELS	ALL SITES	7	56	5929	(3654)	32040	(11075)	410	(193)	16,6	(13)	2,15	(1,0)	15398	(10821)
MEAN -	excluding Saldanha Mytilus	5,5	43	4042	(1939)	31124	(9609)	437	(195)	18	(15)	1,78	(0,65)	6500	(3383)
GUNNAREA CAPENSIS	BLOUBERG	5	85	N.A	**	51109	(18813)	605	(247)	35	(22)	0,71	(0,45)	...	...
GUNNAREA CAPENSIS	DIDO VALLEY	5	78	N.A	**	61454	(4991)	650	(269)	40	(29)	0,68	(0,48)	...	...
MEAN - GUNNAREA	ALL SITES	5	82	N.A	**	56282	(11902)	628	(258)	38	(26)	0,69	(O,47)	...	...

Mean values (SD)

* Data from Davies 1984.

** Numbers of Gunnarea were not determined, because many of the tubes were unoccupied, and some worms retreated into tubes outside the quadrat.

and few of the remainder will survive to reattach and rebuild their tubes. Moreover, this study illustrates the minimum extent of the damage caused, as patches cleared within mussel beds and Gunnarea reefs may be further enlarged by wave shock (Dayton, 1971), which may cause the community to peel back from the edges of the cleared zone, resulting in far greater mortality than that immediately inflicted during bait collecting itself.

Patches of bare substratum within Mytilus californianus beds were found by Paine and Levin (1981) to fill in by three mechanisms, depending on patch sizes. Very small patches (<,01m^2) disappeared almost immediately, due to the leaning response of bordering mussels. Intermediate-sized patches (<3m^2) were eventually filled by lateral movement of adjacent mussels, the rate depending on the depth of the adjacent mussel bed. Very large patches, however, only began to show recovery after 26 months, as recolonization was dependent on larval recruitment, total recovery occurred within 5 to 7 years.

Lambert and Steinke (1986) found in their study on the effects of destroying mussel-dominated and coralline algal communities at Umdoni Park, Natal that Perna perna never returned to numerical dominance in experimental plots of 1,6m^2 during the experiment and up to eight years later.

The objective of conservation is to retain ecological diversity while maximising sustainable utilization. This can be achieved by allowing non-detrimental exploitation by the public , such as picking individual mussels. This process is far less damaging than clearing patches, as natural mortality due to intraspecific competition for space is high anyway and can be substituted by selective human predation (Griffiths & Hockey

1987).Such exploitation can be sustained so long as the area is actively protected by legislation or reserves.

Exploitation legislation varies depending on the authorities responsible for the area, eg. in the Cape Peninsula and Transkei there is no permit system for "casual" exploitation, but bag and size limits, as well as closed seasons are specified. The baglimit for black mussels is 25 per person per day and for bait worms 20 per person per day. In Natal and the Ciskei similar measures are taken, but permits are required for all forms of collecting except sea urchins (Parechinus angulosus) and red bait (Pyura stolonifera). The collection of marine worms is prohibited in this area.

The management implications of this finding are clear: potentially large - scale mortality is inadvertently caused by bait worm gatherers and this is perfectly legitimate. This mortality is at least two orders of magnitude greater than that which is permitted when targetting directly on the mussels, suggesting that it may be time to reconsider the legislative measures controlling this type of activity.

Research is now needed to determine the extent or intensity of mussel worm collection as well as the ecological consequences of removing Gunnarea and different mussel species.

ACKNOWLEDGEMENTS:

Thanks are due to Miranda Waldron, Karen Harmer,Corine van Erkom Schurink and Rod Bally for assistance in the laboratory and field, as well as to Charles Griffiths, Phil Hockey and Bruce Bennett for their useful and informative advice. Finally, thanks to the ESKOM weatherstation team at Koeberg for allowing sampling in the area within the jurisdiction of ESKOM. Funding for this study was provided by the Sea Fisheries Research Institute.

Chapter 8

Discussion and management implications

Discussion and management implications:

Tourism and recreation:

Today all people except the extremely poor and disadvantaged behave as tourists at times. This is reflected by the fact that the travel industry is the third largest retail and service industry in America. Even in the most difficult times, travel and tourism are appealing activities, as was reflected during the 1982 recession when the global travel volume consisted of 2.89 billion arrivals, equivalent to travel expenditure of $983 billion. By a conservative estimate, arrivals will exceed 4 billion, equivalent to an expenditure of more than $1 trillion in 1989 (Miller 1986).

Tourism, associated with the marine environment and its natural and cultural resources can include a variety of activities, some of which bare enormous financial and social implications (eg. marina, hotel and harbour developements). Such tourism has positive and negative effects, changing the quality of life for local populations as well as the natural environment that is the resource base of all this spending and activity. Marine tourism is both a cause and consequence of congestion in centres of human activity, while it is an established fact that recreational activity acts as a social release mechanism (Malan 1983, in Glassom & McLachlan 1989) and therefore plays an important role in society.

Increased recreational pressure in coastal areas adjacent to resort towns has resulted in a degradation of the resource base in many areas and consequentially in a reduction of the quality of the very recreation experience it purports to support (Sowman 1987). UNEP has identified two objectives for sustainable tourism: to promote and enhance tourist resources in harmony with the resource base and to preserve tourism against conflicting activities and their adverse effects, as tourism will ultimately provide greater net social benefit than most other conflicting uses (Miller 1986). For example Australia's Great Barrier Reef Park is benefitting economically from the combination of regulated tourism and enhanced protection of the natural environmental assets on which this tourism is based (Broadus 1987). Similarly, in the Galapagos tourism has shown an average 24% annual growth between 1976 and 1980, thereby surpassing the farming and fishing industries as a source of employment (Broadus 1987).

Many statistics of recreation do not show the marked seasonal, weekly and daily variations that occur due to climate and social pattern (Boden & Ovington 1973). Surveys of beach recreation conducted in Port Elizabeth (Glassom & McLachlan 1989) and Cape Town (van Herwerden et al 1989) showed that peak utilization occurs when good weather coincides with public holidays. In Port Elizabeth the maximum number of recreationists on the beach occur at 11 am (Gibbon 1976, Glassom & McLachlan 1989), whereas Cape Town beaches reach maximum numbers at 2 pm (Beavon 1968, van Herwerden et al 1989). In both areas sunbathing and passive recreation were the major activities. In New South Wales, Australia, a 1981 census showed that 37% of all dwellings in a coastal resort town were unoccupied for most of the year, but during peak holiday periods the population of the resort increased by nearly 300% (Yapp 1986).

Monitoring environmental change that results from recreational activities is problematic for various reasons:

- There is a complex web of interactions between the components of an ecosystem, making it difficult to isolate a particular variable and its variation.
- The fluctuating nature of ecosystems makes it extremely difficult to define a base level against which man-induced change can be measured.
- Recreation activities and intensities vary greatly over time.
- Some ecosystems react slowly to recreation pressure, so that changes only occur at a later stage, which makes it difficult to establish a cause-effect relationship between recreation activity and ecological degradation (Sowman 1987).

Conservation aspects:

To make any significant impact and progress, conservation is and has to be a political issue, as the benefits of untransformed ecosystems have been considered as dispensable relative to the benefits gained from ecosystem-destructive activities (Siegfried & Davies 1982). At the same time conservation issues cannot be expected to be a high priority amongst people whose basic economic and nutritional needs are not met (Johannes & Hatcher 1986, in Hockey & Buxton 1989).

Reserve areas are subjected to many changes, ranging from natural to human-caused, manageable to unmanageable and beneficial to detrimental, so that the goal of preserving systems that must change is paradoxical, as management itself introduces human influence into natural ecosystems. However, as it is virtually impossible to remove all human influences from reserves, both direct and indirect impacts of human activities must be monitored as well as natural changes in areas that are perceptibly changing and areas that are not perceptibly changing (White & Bratton 1980). Along the False Bay shoreline monitoring of the intertidal communities on the rocky western shores has been in progress since 1987, however it is not possible to draw any conclusions from this data at this stage, as the natural levels of variation are very high and a longer time series (at least five years) is needed to detect any recovery in the intertidal communities of reserve areas, as opposed to areas that are not conserved. This is further complicated by the fact that there is negligible enforcement in the conservation areas along this section of the coast, so that conservation areas are still under exploitation pressure, as discussed in chapter 2.

It is questionable whether our conservation priorities and philosophies are able to keep abreast with an urbanizing South Africa where political and social issues are first priorities to the majority of our population. There is a serious lack of understanding in South Africa of the relationship between human behaviour and environmental conservation (Ferrar 1983). Most South Africans are uninformed or unaware of their total dependence on the well-being of their natural environment. Even if people are aware, they are unwilling to do anything about it in practice. The inevitable result is that the sustainability of South Africa's natural environment is steadily declining (Ferrar 1983). Something which is detrimental not only to the natural ecosystems, but to its dependent human population as well. "Conservation awareness" of respondents to a questionnaire survey undertaken along the western shores of False Bay, was significantly related to place of residence ($p < 0.05$), with those respondents living within the False Bay coastal zone being more aware of the conservation of the shore, than respondents living further afield (chapter 4). It was found, however, that the erection of improved signs in 1988 in the conservation areas, did result in an improved awareness of respondents, though this may also simply be ascribed to the increased proportion of respondents from the greater Cape Town region in the 1989 questionnaire survey (80%), compared to the 1987 survey (66%) (Chapter 4).

The coastal zone is home to more than 50% of the people on earth and as such it is as threatened as tropical forests and other endangered environments, but it receives very little attention from conservation agencies (Siegfried & Davies 1982). Far from being a luxury, conservation of the coastal zone is a neccessary expense for our generation, both in terms of financial and social gains.

The shoreline is under constant threat from human activities that may cause damage indirectly, such as through use of off road vehicles and trampling or directly, by exploitation of the resources of the marine environment.

Exploitative activities:

Along the west coast of South Africa nutrient-rich upwelling results in high primary productivity of the coastal waters. This is where the commercial fishing industry is most active, though commercial shrimp, squid and sole fisheries do occur further east. In False Bay the commercial linefishery has undergone vast changes, as is reflected by the following statements from Penney et al (1989):

- In 1687 Governor Simon van der Stel recorded the following statement during an expedition into False Bay: "It was so easy to catch them (reef fish), one could not quickly enough throw the hooks into the water in order to draw them up again..."
- Red Stumpnose (Chrysoblephus laticeps) were known to migrate towards the end of summer, into False Bay, in vast numbers, in the 1920's and large numbers were caught near Kalk Bay.
- Yellowtail (Seriola pappei) entered False Bay in huge shoals and were fished in the vicinity of Kalk Bay, where large catches of White Stumpnose (Rhabdosargus globiceps) were also made nightly from the pier.
- In the early 20th century Elf (Pomatomus saltatrix) were netted by the tens of thousands in False Bay.

By the 1930's catches in False Bay were on the decline, a situation which has not improved over the past decades, both catch rates and sizes of many South African reef fish being well below past averages.

Recreational rock and surf anglers in South Africa were estimated to total 288 000 for 1987, while 4000 spearfishermen were estimated to be active in South Africa during 1987 (van der Elst 1989). There are two major trends in the catches of recreational anglers:

- The overall catch rate is declining;
- The catch composition is changing, with a decline in the endemic bony fish catches and an increase in the catches of cartilagenous sharks and rays (van der Elst 1989, Bennett 1989).

Preliminary results of a fish census undertaking in the Castle Rocks marine reserve and adjacent reefs outside of the reserve seem to indicate that the species diversity is slightly lower outside the reserve than within (22% lower, Chapter 5). This census has also revealed thusfar that although certain species such as Roman (Chrysoblephus laticeps) and Hottentot (Pachymetopon grande) occured variably both within and outside the reserve, Red Stumpnose (Chrysoblephus globiceps) was not observed outside the reserve at all, although up to 100 individuals had been seen inside the marine reserve during the census period. Unfortunately, the coefficient of variation of the fish census data is very high (ranging between 37 and 400 %), so that the data cannot be statistically verified, unless an extensive census is undertaken, (which was outside the scope of this programme), thereby reducing the coefficient of variation to an acceptable level (Chapter 5).

The intertidal communities of the False Bay shoreline have a high species diversity, with the lowest numbers of species occurring on unstable boulder beaches. Even areas known to suffer from heavy collection pressure, such as Dalebrook (before it was proclaimed a marine reserve), don't have lower species richness than inaccessible sites, such as Robben Island, which was found by Branch & McQuaid to have 90 species (Branch 1980). They found during their survey of rocky shores that there was no sign of rocky shores being denuded, however, if particular species are singled out, there is a different scenario: rock lobster (Jasus lalandi) and perlemoen (Haliotis midae) of legal size are difficult to find in False Bay. However, an examination of the perlemoen distribution in the marine reserve at Betty's Bay, would show how rich the perlemoen distribution may once have been. Also alikreukel (Turbo sarmaticus) populations are reduced in size and numbers in most accessible areas (Branch 1980, Branch

& Moreno 1989).

Shellfish populations are targets of both commercial and recreational / casual exploiters. The economic value of these resources is high, as is reflected by the 1983-4 income of the lobster industry (based on the West coast), which amounted to R117 million, while the abalone industry (based on the South coast) earned R5 million (Hockey 1989). Although man is still essentially a hunter-gatherer in the marine environment, relying on the natural productivity of the marine environment, aquaculture is a growing industry in South Africa, which is limited at this stage to mussels, clams and oysters (Hockey 1989).

Man is still largely ignorant of the effects of his activities on the structure and dynamics of marine ecosystems, although it is possible that his selective predatory behaviour will alter the natural equilibrium, thereby reducing the reproductive output of exploited populations (Hockey 1989).

Intertidal communities form a patchwork of space-occupying and space-creating organisms, with space that is intensely competed for being rapidly colonized whenever free space becomes available (Branch & Moreno 1989, Hockey 1989a, Hockey 1989b). The colonizing species are normally different to the exploited species which are replaced, eg. algae or barnacles will replace mussels. The result of such replacement is an overall reduction in the quality of the shore as a source of food for man, which results in increased exploitation pressure on the remaining food organisms (Hockey 1989a).The long term effects of such disruptions to intertidal communities is not known. However, recent studies have shown that ongoing exploitation of intertidal communities by man does have a major impact on the structure and functioning of the community (Hockey 1989b, Lasiak & Dye 1989), although recovery does occur again when exploitation ceases (Moreno et al 1984, Castilla & Duran 1985, Oliva & Castilla 1986).

There are three buffers preventing species extinctions and irreversible changes due to exploitation by man:
- Most molluscs become reproductive at a young age and small size, so that high densities of small animals have a reproductive output per unit area of shore that approaches or may even exceed that of the larger, less dense adult populations (Hockey & v.Erkom Schurink in press).
- Many of the species preyed on have a proportion of the population in the infratidal region, so that this stock is relatively free of exploitation pressure and is able to provide recruits to replenish the depleted intertidal stocks.
- There are extensive parts of the coastline that are sparsely populated by humans, or inaccessible to man due to the geomorphology. Populations of intertidal organisms from these areas may provide a source of recruitment for the exploited sections of the shoreline, thereby preventing long-term species extinctions and irreversible disequilibrium (Hockey 1989b).

The greatest exploitation pressure along the South African coast, is along the Eastern Cape, the Ciskei and the Transkei (Hockey et al 1988, in Hockey & Buxton 1989). Hockey and Bosman (1986) found along the Transkei coast that exploitation has resulted in increased sessile, inedible forms. Extensive mussel beds are only found inside nature reserves and at inaccessible areas, as mussels form a significant proportion of animal protein intake of the indigenous Transkeian populace (Lasiak & Dye 1989). Exploitation can also have beneficial side effects, for example, decreased densities can enhance the growth and body mass of the remaining grazing gastropods. (Branch & Moreno 1989, Hockey 1989b). It must be noted however, that recruitment in some species such as Haliotis and Patella is dependent on the presence of a local population of adults at a certain density to stimulate spawning; thus it cannot be taken for granted that all broadcast spawners have a prolonged larval stage (Branch & Moreno 1989).

Management implications:

The marine, coastal and terrestrial environments need to be managed as a unit, as these systems are interdependent (Hockey & Buxton 1989, Malan 1982). Presently common law excludes the coastal area below the highwater mark from nature reserves, Tsitsikamma National Park is the only exception, as it incorporates a marine reserve proclaimed under the National Parks Act (Hockey & Buxton 1989). Only if authority for the protection of the seashore in South Africa is altered, so that nature reserves on the coast are extended seawards, will adequate conservation be achieved along much of the South African coast (Hockey & Buxton 1989). The Cape Peninsula coast is one of twelve recommended marine and adjacent onshore conservation areas to receive special attention for conservation purposes; this area includes Table Mountain, the Cape Peninsula, Robben Island, False Bay and east to the Bot River estuary (Robinson 1989).

Goals for the establishment of marine parks include the protection of vital marine resources, species preservation and the provision of areas in which comparable baseline data can be gathered for research, recreation and education (Broadus 1987). However, protected areas must be philosophically competitive at the market place as well, as cost-benefit analysis is often used to weaken support for protected areas. In a period of shrinking budgets and global inflation it is important that governments budget for the support of protected areas, because conservation of our resource bases is as important as defense, education and public health (McNeely & Miller 1983). In fact, action similar to the World Wildlife Fund for endangered species is required for attractive landscapes, such as coastal districts and beaches, as these areas are magnets for tourism and need to be maintained, even if only for the sake of tourism (Benthem 1973).

Inefficient management results when there is a lack of cooperation among conservation agencies. In South Africa there is also an inefficient conservation strategy due to legislative confusion and the advice of marine scientists being largely ignored (Hockey 1989a). Unless the legislation is enforceable and the objectives are clearly understood, conservation policy cannot be effective. It has been repeatedly noted during the course of this study, that due to the poor enforcement of conservation regulations in False Bay, exploitation of both intertidal organisms as bait or food and of subtidal organisms (by snorkel divers and spearfishermen), continues in the conservation areas.

A critical evaluation is needed of the effectiveness of the marine reserve network existing in South Africa. From such a basis, marine conservation policy can then be formulated, incorporating socio-economic, as well as conservation aspects, which should then be coordinated by one body, as fragmentation has resulted in inadequate conservation strategy (Hockey 1989a).

adapt their lifestyles (Time International 1989).

Protected areas can be managed to meet recreational needs, while providing for conservation education; in this manner such areas can contribute to the experience and understanding of life systems and ecological processes, without which our society is unlikely to make the neccessary decisions to ensure the continued functioning of the biosphere (Siegfried & Davies 1982). Recreation planners and decision makers are confronted by the conflicting forces to meet the demands of an increasing recreational population, which requires the expansion of existing facilities and the provision of additional outlets along the coast, on the one hand, while there is a positive drive to conserve the coastal resources in order to maintain the scenic qualities and natural attributes that attract tourists to the coast, on the other hand (Sowman 1987). It is imperative that a suitable balance be achieved between developement and conservation, with environmentally and ecologically sensitive areas being identified and excluded from the developement pressure, while providing for the economic and social needs of the community. Furthermore, the Ultimate Environmental Threshold (UET) level of areas that are to be developed, should not be exceeded, ie. exploitation or use of the ecosystem must not exceed the natural homeostatic controls of the ecosystem (Rosier et al 1986).

Under the pressure of expanding tourism & recreation, human activities will need to be regulated as best to minimize the negative impacts on natural ecosystems, by reducing or limiting the absolute numbers of people and by channelling their activities. The numbers of visitors to an area can be controlled to some extent by providing:

- many versus few access points to a particular shoreline.
- wide concrete stairways versus steep rocky paths at access points.
- ample versus limited parking space.
- ample versus few facilities such as food stands and ablution blocks.

Furthermore, areas can be conspicuously signposted or left inconspicuous. In this manner visitor activity can be concentrated in a few areas or spread over a large area (Ghazanshahi et al 1982).

A serious management and economic problem in the field of outdoor recreation, is the extreme time peaking of recreation demand. It is at times of maximum recreational use that site deterioration is most likely to occur due to over use (Boden & Ovington 1973), with a resultant decline in both the recreation experience and conservation. The perception of a good quality recreation experience depends on many factors and varies from person to person, as well as from time to time for the same person (Sowman 1987). To attempt to alleviate this problem a greater knowledge of recreational behaviour is needed, for the management of semi-natural areas. Greater attention should also be paid to the temporal and spatial patterns of recreational activities, so that peak periods of use can be identified. The field of recreation is rapidly growing and changing in nature, so that management plans for recreation / conservation areas must be dynamic and long-term.

Multiple-use management areas, such as False Bay, can provide for sustained production and outdoor recreation, with nature conservation being primarily oriented to support economic activities such as tourism and exploitation, though specific areas may be designated within such an area to achieve specific conservation objectives (McNeely & Miller 1983). Man-modified sites should be included when ecosystems are selected for conservation, even areas that have been considerably disturbed, while bearing in mind the effects of human activities on such ecosystems. There is as much need to study the recovery of biotic communities as there is to study natural processes. However, too many sites should not be selected, as research and management institutions will not be able to do an efficient job. When designing marine reserves, the advantages of having one large permanent reserve should be weighed up against having a series of smaller reserves at different locations in different years (Siegfried & Davies 1982). The large reserve may provide maximum species diversity according to Siegfried & Davies (1982) and seeding of outlying areas. However, Branch & Moreno (1989) noted that species richness is increased in exploited areas, which indicates that the oft-quoted goal of reserves to increase species diversity is not neccessarily desirable in the context of both conservation and exploitation.

The "island effect" of protected areas must be reduced as far as possible by carefully regulating land and water uses in the vicinity of protected areas. Thus a network of reserves is needed that will balance processes of immigration and local extinction on the basis of island biogeography theory (Paine & Levin 1981). However, as the extent of the dispersive capabilities of the biota varies dramatically amongst intertidal species, it is not known what the ideal reserve size and spacing should be (Hockey &

Buxton 1989). It is therefore necessary that management decisions should allow for the inclusion of a safety factor, to allow for the limited extent of our knowledge (Heydorn 1983, in Hockey & Buxton 1989). In order to optimize a "backbone" reserve network, dispersal patterns and immigration rates of exploited species need to be established. On this basis guidelines can be established for the sizing and spacing of marine reserves in the network. Furthermore, site selection of reserves can be optimized by establishing what the geological influence is on community structure (Hockey & Buxton 1989). Natural changes within intertidal communities in undisturbed areas should be established by long-term monitoring, otherwise such changes may be attributed to disturbance or exploitation by man. There should also be an assessment of the ecological impact of recreational activities, such as ORV's, trampling, bait collection and rock or shore angling, on coastal biota. All such research projects should be coordinated at a national level, to ensure that a sufficient geographical range is covered and that results obtained are directly comparable.

Acknowledgements:

I am grateful to my supervisor Prof. C.L. Griffiths for providing a driving force throughout this project. I would also like to thank Prof. J.G. Field, Dr. P.A.R. Hockey, Dr. M. Gibbons, Mr. B. Bennett, Ms J. Sommerville and Mr. A.J. Penney for their time and advice. The project was funded by the Sea Fisheries Research Institute and I thank them for making this study possible.

References:

Anderson, S.H. 1980. The role of recreation in the marine environment. Ocean Yearbook 2, eds. Borgese, E.M., Ginsburg, N. the University of Chicago press, Chicago.

Anonymous 1986. Projections of the population of the Cape Town land use/ transport study area 1980-2000. Metropolitan transport planning branch. City Engineer's Department, Cape Town.

Anonymous 1986. Republic of South Africa population census 1985, Report no. 02-85-02. Age by development region, statistical region & district central statistical services, Pretoria 25 Sept.1986.

Anonymous 1987. Symposium on conservation in an urbanising environment: the Greater Cape Town Region. University of the Western Cape, September 1987

Anonymous 1986.(Unpublished Report) Cape Metropolitan Planning Committee.

Bally, R. & Griffiths, C.L. 1989. Effects of human trampling on an exposed rocky shore. International Journal of Environmental studies 34: 115 - 125.

Bally, R., Brown, A.C., McQuaid, C.D. 1984. Shores of mixed sand and rock: an unexplored ecosystem. South African Journal of Science, 80: 500 - 503.

Beauchamp, K.A. & Gowing, M.M. 1982 A quantitative assessment of human trampling effects on a rocky intertidal community. Marine

Environmental Research 7 (4): 279 - 293.

Beavon, K.S.O. 1968. Greater Cape Town region recreation and tourism. Planning Report 5. Provincial Administration of the Cape of Good Hope.

Benthem, R.J. 1973. Recreational and environmental planning. Biological Conservation 5 (1): 1 - 5.

Bennett, B. 1989 Has rock and surf fishing in the Southwestern Cape deteriorated since 1938? False Bay twenty years on - an environmental assessment, Newlands, Cape Town September 1989.

Bigalke, E.H. 1973. The exploitation of shellfish by coastal tribesmen of the Transkei. Annals of the Cape Provincial Museums (natural history) 9 (9): 159 - 175.

Blomberg, G.D. 1982. Coastal amenities and values: some pervasive perceptions expressed in literature. Coastal Zone Management Journal 10 (1/2): 53 - 78.

Boden, R.W. & Ovington, J.D. 1973. Recreation-use patterns and their implications for management of conservation areas. Biological Conservation 5 (4): 265 - 270.

Bosman, A.L. & Hockey, P.A.R. 1986. Seabird guano as a determinant of rocky intertidal community structure. Marine Ecology Progress Series 32: 247 - 257.

Branch, G. 1980. Aquatic fauna and flora In: The Future Management of False Bay - Proceedings of a seminar held on 11 June 1980 in Cape Town, B. Gasson (ed.), Department of urban and regional planning, University of Cape Town.

Branch, G.M. & Moreno, C.A. 1989 (in press) The Ecological consequences of exploiting intertidal and near-shore grazers.

Branch G.M. 1985. Competition: Its role in ecology and evolution in intertidal communities. In: Vrba E.S. (ed.) Species and speciation. pp. 97 - 104. Transvaal Museum monograph 4. Transvaal Museum, Pretoria.

Branch, G.M. and C.L. Griffiths 1988. - The Benguela ecosystem, 5 The coastal zone. In Oceanography and Marine Biology. An Annual Review Barnes, M. (Ed.) 26: 395 - 486.

Broadus, J.M. 1987. The Galapagos Marine Resources reserve and tourism developement. Oceanus 30: 83 - 86.

Bryceson, I. 1981. A review of some problems of tropical marine conservation with particular reference to the Tanzanian coast. Biological Conservation 20 (5): 163 - 171.

Buxton, C.D. & Smale, M. 1989. Abundance and distribution patterns of three temperate marine reef fishes (Teleostei: Sparidae) in exploited and unexploited areas off the southern Cape coast. Journal of Applied Ecology 26 (in press).

Castilla, J.C & Duran, L.R. 1985. Human exclusion from the rocky intertidal zone of Central Chile: the effects on Choncolepas choncolepas (Gastropoda). Oikos 45: 391 - 399.

Castilla J.C. 1988. Earthquake-caused coastal uplift and its effects on rocky intertidal kelp communities. Science 242: 440 - 443.

Collins 1956. Collins New English Dictionary

Connell, J.H., 1978. Diversity in tropical rain forests and coral reefs. Science 199: 1302 - 1310.

Connor, E.F. & McCoy, E.D., 1979. The statistics and biology of the species - area relationship. The American Naturalist 113 (6): 791 - 833.

Davies, N.M. 1984. A survey at exploited and unexploited sites of the intertidal community at De Hoop nature reserve. Unpublished Honours Project, Department of Zoology, University of Cape Town: 23 pp.

Dayton, P.K., 1971. Competition, disturbance and community organization: the provision and subsequent utilization of space in a rocky intertidal community. Ecological Monographs 41 (4): 351 - 389.

Drake, C. 1982. Controversy over the use of a coastal state park Coastal Zone Management Journal 10 (1/2): 97 - 123.

Duran, L.R., Castilla, J.C., Oliva, D. 1987. Intensity of human predation on rocky shores at Las Cruces in central Chile. Environmental Conservation 14 (2): 143 - 149.

Ferrar, A.A. (ed.) A South African Perspective on conservation behaviour - a programme description. South African National Scientific Programmes Report 76.

Field, J.G., Clarke, K.R., Warwick, R.M., 1982. A practical strategy for analyzing multispecies distribution patterns. Marine Ecology Progress Series 8: 37 - 52.

Gaigher, C.M. 1979. Aspects of the population dynamics and ecology of the bloodworm Arenicola loveni. Unpublished MSc thesis, University of Cape Town.

Ghazanshahi, J., Huchel, T.D. & Devinny, J.S. 1982. Alteration of a southern California rocky shore ecosystem by public recreational use. Journal of Environmental Management 16: 379 - 394.

Gibbon, A.B. 1976. Outdoor recreation survey of the Port Elizabeth area. Unpublished MA thesis, University of Port Elizabeth.

Glassom, D. & McLachlan, A. 1989. Recreation on Port Elizabeth beaches - December / January 1987/8. Institute for Coastal Research, University of Port Elizabeth Report 19.

Griffiths, C.L. and P.A.R. Hockey 1987. A model describing the interactive roles of predation, competition and tidal elevation in structuring mussel populations. In The Benguela and Comparable Ecosystems. Paine, A.I.L., Gulland, J.A. and K.H. Brink (Eds). South African Journal of marine science 5: 547 - 556.

Heath, R. 1987. Impact of trampling and recreational activities on the littoral active zone - a literature review. Institute for Coastal Research. Report 15, University of Port Elizabeth.

Hockey, P.A.R. 1989. Coastal and marine conservation in South Africa: Towards a strategy for the 21st century. In: Cooper, K. (ed.) Proceedings of a Symposium on Conservation Priorities in

South Africa, Durban: Wildlife Society of South Africa.

Hockey, P.A.R. 1989. (in press) Violating evolutionary rules: man vs natural predators in the intertidal zone.

Hockey, P.A.R. & Bosman, A.L. 1986. Man as an intertidal predator in Transkei: disturbance, community convergence and management of a natural food resource. Oikos 46: 3 - 14.

Hockey, P.A.R. & Buxton, C.D. 1989. Conserving biotic diversity on Southern Africa's coastline. In: Huntley, B.J. (ed.) Biotic diversity in Southern Africa Cape Town: Oxford University Press.

Hockey, P.A.R. & van Erkom-Schurink, C. 1989. The invasive biology of the mussel *Mytilus galloprovincialis* on the southern African coast. Transactions of the Royal Society of South Africa (in press).

Kayes, R. 1987. Britain tests the water for marine conservation. New Scientist, June 1987, 48 - 52.

Lambert, G. and T.D. Steinke 1986. Effects of destroying juxtaposed mussel-dominated and coralline algal communities at Umdoni Park, Natal Coast, South Africa. South African Journal of marine science 4: 203 - 217.

Lasiak, T. & Dye, A. 1989. The ecology of the Brown mussel *Perna perna* in Transkei, Southern Africa: Implications for the management of a traditional food resource. Biological Conservation 47: 245 - 257.

Linden, E. 1989. Endangered earth. Time International 2 January : 18 - 21.

Littler, M.M. & Littler, D.S. 1981. Intertidal macrophyte communities from Pacific Baja California and the Upper Gulf of California: relatively constant vs environmentally fluctuating systems. Marine Ecology Progress Series 4: 145 -158.

MacArthur, R.H. & Wilson, E.O. 1967. The theory of island biogeography. Princeton University Press, 1967.

Malan, J.S.E. 1982. The formulation of an administrative structure for the management of False Bay. School of Environmental Studies Research paper 35 University of Cape Town.

Margules, C. & Usher, M.B. 1981. Criteria used in assessing wildlife conservation potential: a review. Biological Conservation 21: 79 - 109.

McGuinness, K.A. 1987 a. Disturbance and organisms on boulders. I Patterns in the environment and the community. Oecologia 71: 409 - 419.

McGuinness, K.A. 1987 b. Disturbance and organisms on boulders. II Causes of patterns in diversity and abundance. Oecologia 71: 420 - 430.

McGuinness, K.A. & Underwood, A.J. 1986. Habitat structure and the nature of communities on intertidal boulders. Journal of Experimental Marine Biology and Ecology, 104: 97 - 123.

McNeely, J.A. & Miller, K.R. 1983. IUCN, National parks and protected areas: priorities for action. Environmental Conservation 10 (1): 13 - 21.

McQuaid C.D. & Branch G.M. 1985. Trophic structure of rocky intertidal communities: response to wave action and implications for energy flow. Marine Ecology Progress Series 22: 153 - 161.

Miller, M.L. 1986. Travel tourism and marine affairs. Coastal Zone Management Journal 14 (1/2): 53 - 78.

Moreno, C.A., Sutherland, J.P., Jara, F.H. 1984. Man as a predator in the intertidal zone of southern Chile. Oikos 42: 155 - 160.

Paine, R.T. & Levin, S.A. 1981. Intertidal landscapes: disturbance and the dynamics of pattern Ecological Monographs 51 (2): 145 - 178.

Penney, A.J., Buxton, C.D., Garrat, P.A. & Smale, M.J. 1989. The commercial marine line fishery. In: Oceans of life off southern Africa A.I.L. Payne & R.J.M. Crawford (eds.) Vlaeberg Publishers, Cape Town.

Robinson, G.A. 1989. Marine reserves. In: Oceans of life off southern Africa A.I.L. Payne & R.J.M. Crawford (eds.) Vlaeberg Publishers, Cape Town.

Rosier, J., Hill, G. & Kozlowski, J. 1986. Environmental limitations: a framework for development on Heron Island, Great Barrier Reef. Journal of Environmental Management 23: 59 - 73.

Siegfried, W.R. & Davies, B.R. (eds.) 1982. Conservation of ecosystems: Theory and practice. South African National Scientific Programmes Report 61

Siegfried, W.R., Hockey, P.A.R., Crowe, A.A. 1985. Exploitation and conservation of brown mussel stocks by coastal people of the Transkei. Environmental Conservation 12: 303 - 307.

Sousa, W.P. 1979a. Experimental investigations of disturbance and ecological succession in a rocky intertidal algal community. Ecological Monographs, 49 (3): 227 - 254.

Sousa, W.P. 1979b. Disturbance in marine intertidal boulder fields: the nonequilibrium maintenance of species diversity. Ecology, 60 (6): 1225 - 1239.

Sowman, M.R. 1987. A procedure for assessing recreational carrying capacity of coastal resort areas. Landscape and Urban Planning 14: 331 - 344.

Sowman, M.R. 1984. An assessment of recreational carrying capacity at Infanta, Southern Cape. University of Cape Town School of Environmental Studies, Research report 57.

Sunter, C. 1987. The world and South Africa in the 1990's. Human & Rousseau, Tafelberg Publishers, Cape Town.

Taylor, P.R. & Littler, M.M. 1982. The roles of compensatory mortality, physical disturbance, and substrate retention in the development and organization of a sand - influenced rocky intertidal community. Ecology, 63 (1): 135 - 146.

Thresher, R.E. & Gunn, J.S. 1986. Comparative analysis of visual census techniques for highly mobile, reef associated piscivores (Carangidae). Environmental Biology of Fishes 17 (2): 92 - 116.

van der Elst, R. 1989. Marine recreational angling in South Africa. In: Oceans of life off southern Africa A.I.L. Payne &

R.J.M. Crawford (eds.) Vlaeberg Publishers, Cape Town.

van der Merwe, D. 1988. Effects of off road vehicles on coastal ecosystems - a review. Institute for Coastal Research Report 17: University of Port Elizabeth.

van Herwerden, L. 1989. Collection of mussel worms (Pseudonereis variegata) for bait - a legislative anachronism. South African Journal of Marine Science (in press).

van Herwerden, L. & Bally, R. 1989. Shoreline utilization in a rapidly growing, coastal metropolitan area: the Cape Peninsula, South Africa Journal of Ocean and Shoreline Management 12: 169 - 178.

van Herwerden, L., Bally, R., du Plessis, C., Blaine, M. Griffiths, C.L. 1989. Shore utilization patterns in a metropolitan area, the Cape Peninsula, South Africa. Journal of Ocean and Shoreline Management (in press).

White, P.S. & Bratton, S.P. 1980. After preservation: philosophical and practical problems of change. Biological Conservation 18: 241-255.

Wolcott, T.G. & Wolcott, D.L. 1984. Impact of off road vehicles on macro-invertebrates of a mid - Atlantic beach. Biological Conservation 29: 217 - 240.

Yapp, G.A. 1986. Aspects of population, recreation and management of the Australian coastal zone. Coastal Zone Management Journal 14 (1/2): 47 - 66.