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Social Carrying Capacity as a Management Tool for Sandy Beaches

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ABSTRACT

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The social carrying capacity (SCC) of three South African sandy beaches with different levels of development was estimated from beach users' crowding perception at different densities. This was obtained by questionnaire survey and hourly beach visitor counts on 26 December 1992 and 1 January 1993, the two most popular days for visiting the beach.Because of patchy distribution of visitors with aggregation around entrances and lifeguard zones, we distinguished between beach visitor density (total number of visitors counted on the beach per beach surface area) and patch visitor density (the actual density observed by interviewers in 10 × 10 m blocks). Beach visitor density was always lower than patch visitor density, confirming the patchy visitor distribution. The smallest of the three beaches showed the highest mean beach and patch visitor densities on both days and the highest maximum patch visitor density (40 individuals per 100 m^2 on 26 December 1992) due to a volley ball tournament held on the beach.Estimates of SCC were expressed in two forms. Abundance social carrying capacity (ASCC) was obtained from the visitor abundance on the entire beach, and patch density social carrying capacity (PDSCC) from visitor densities in 10 × 10 m blocks at times when most respondents felt comfortable with the number of visitors on the beach on 1 January, the most crowded day. Patch density SCC was lower on the less developed than on the more developed beaches, demonstrating the importance of facilities and crowd-attracting activities in regulating SCC. We conclude that external factors such as facilities, crowd-attracting activities, beach and visitor group size enhance social carrying capacity. Furthermore, SCC can be a powerful managing tool when used together with ecological carrying capacity to determine level of beach development.

ADDITIONAL INDEX WORDS: *Crowding perception, development, beach recreation, coastal management, personality types, crowding tolerance, South Africa.*

INTRODUCTION

The social carrying capacity (SCC) or perceptual carrying capacity of sandy beaches, the maximum visitor density at which recreationists still feel comfortable and uncrowded, is one of several components of recreational carrying capacity (BROTHERTON, 1973; HEBERLEIN, 1977). SCC is a dynamic concept set by crowding perception and territorial spacing which vary according to several factors such as the personality type, sex, group size, cultural and even occupational background (EDNEY and JORDAN-EDNEY, 1974) of the majority of beach visitors present at any time. Yet, with the ever increasing recreational pressure on the coastal zone (MILLER and AUYONG, 1991), the ability to determine carrying capacities of recreational areas has become essential in planning coastal conservation and development.

Several procedures have been developed and applied with a lesser or greater degree of success (THREINEN,1964; AN FORAS FORBARTHA, 1973; JAAKSON *et al.,* 1976; SOWMAN, 1987a and b; SOWMAN and FUGGLE, 1987). Standards of carrying capacities for recreational sites have been determined by several researchers and authorities, although the methods of determination are not always clear (ORRRC, 1963; THREINEN, 1964; FLORIDA RECREATION AND PARK ASSOCIATION, 1975; BAUD-BOVY and LAWSON, 1977; URBAN LAND INSTITUTE, 1981; PEARCE, 1981; SOWMAN, 1987a). Other studies have concentrated on the crowding perception, satisfaction and opinion of recreationists under different densities (AN FORAS FORBATHA, 1973; HEBERLEIN and SHELBY, 1977; WILLIAMS, 1988; HERRICK and MCDONALD, 1992).

Research on population density and crowding and its effect on human behaviour has been reviewed by EDNEY (1977) and problems in this field were discussed by BOOTS (1979). Recreational carrying capacity has been estimated for European and North American beaches (ORRRC, 1963; FLORIDA RECREATION AND PARK ASSOCIATION, 1975; BAUD-BOVY and LAWSON, 1977; URBAN LAND INSTITUTE, 1981) but little is known about the social carrying capacity of South African beaches. The aim of this study was to estimate the SCC of sandy beaches directly from users' opinions, to determine the influence of beach development on SCC and to discuss the importance of SCC in managing the utilization of sandy beaches.

STUDY AREA

King's Beach and Hobie Beach, both situated adjacent to the tourist centre of Port Elizabeth, Eastern Cape, South Af-

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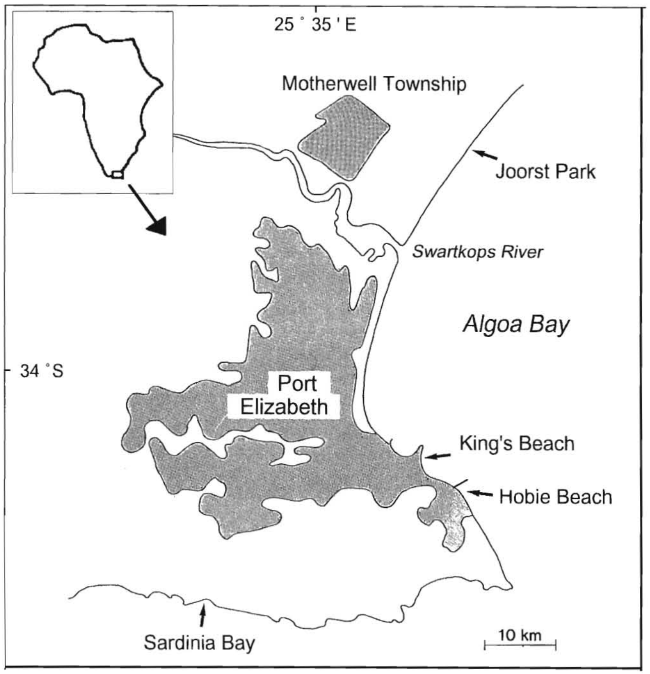

Figure 1. Map to show the position of the study beaches.

rica (34° S, 25° 35′ E) are within walking distance from hotels and holiday accommodation and serviced frequently by the public transport system (Figure 1). They have parking space for 1000 and 500 cars respectively, toilet facilities, showers, kiosks and lifeguard services and no entrance fees are charged. In addition, King's Beach has large landscaped lawns behind the beach, with swimming pools, minigolf facilities, a water slide, go-karts and other games. Facilities for volley ball and other sports are provided on both beaches and volley ball matches and lifesaving competitions are often organised. A pier and seawall is Hobie Beach's main attraction as well as arts and crafts markets and several restaurants and pubs behind the beach. Joorst Park is situated 20 km northeast of the city centre. This beach is regarded as semi-developed with only a parking lot, two lifeguard towers approximately 1 km apart, and a limited number of toilets and showers on the beach. A small holiday resort with a swimming pool, toilets and kiosk is situated 400 m inland behind the foredunes. The general public, however, have no access to these facilities without paying entrance fees and generally reach the beach via a separate road. Tidal range in PE is 1.5m.

With a surface area of approximately 300 000 m^2 between the sea and the dunes, Joorst Park beach was the largest of the three beaches studied, but only a section of approximately 92 000m^2 around the southern lifeguard tower, to which the public had access without paying an entrance fee, was used for the study. King's Beach had a total surface area of about170 000 m^2. However, a section of 60 000 m^2, bordering the foredunes on the northwestern half of the beach, was often flooded during spring tides and remained damp even during neap tides. This part was seldom used by the public, thus the recreationally usable surface area of King's Beach was about 110 000 m^2. The 150 m long section of Hobie Beach used in the study occupied a surface area of approximately 10 000 m^2.

METHODS

To determine the influence of beach development on SCC, questionnaire surveys were completed on 26 December 1992 and 1 January 1993 on Hobie Beach and King's Beach (well developed beaches) and Joorst Park (semi-developed). Beach development was classified comparatively with undeveloped beaches having no facilities, semi-developed beaches having only basic facilities such as parking, toilets and showers in contrast to well developed beaches having facilities additional to the aforementioned. The beach was devided into zones, each zone divided into 10 m wide strips (running parallel from the dunes to the water) by markers along the duneward border. No marking off was done on the beach itself to avoid inhibiting the natural activity and movement of the public. Each interviewer was assigned a zone in which to conduct his survey. Every half hour, they counted the number of people in a randomly chosen block of 100 m^2 (10 × 10 m), the lenght of which they casually stepped off along one of the 10 m strips within their zone after which as many as possible of the persons inside each block were interviewed within that half hour. The total visitor numbers, including bathers, at King's Beach and Hobie Beach were counted from photographs taken every hour from nearby buildings. At Joorst Park the hourly visitor abundance on a section of beach 500 m east and 500 m west from the southern lifeguard tower was determined using binoculars.

Because of patchy distribution with visitors clumping near entrances, toilet facilities and lifeguard zones, we distinguished between visitors densities on the whole beach and in the patches. The mean visitor densities in the patches (persons per 100 m^2) for each half hour was obtained from the half-hourly visitor density values counted by interviewers in each block, summed for interviewers and divided by the number of interviewers on that particular beach. The mean visitor density on the beach was calculated as follows:

$$\text{Mean beach visitor density (persons/100 m}^2) = \text{mean half-hourly number of visitors on entire beach/beach surface area (m}^2) \times 100$$

This estimate assumes that visitors are evenly spread over the entire beach in contrast to the actual density observed within the aggregations of beach users.

Each interview lasted approximately 3 minutes.Time of interview and sex was recorded for each respondent, so that responses could be correlated to visitor abundance and density at the time of interview. The number of questions were limited (Table 1) to obtain as many as possible of the respondents' opinions about their crowding perception within the half hour after determining the density in the patch.

Mean surface areas of the beaches, measured from 1:10 000 and 1:15 000 ortophotos, were obtained from the P.E. City Engineers Department. The last orthophotos were taken in

Table 1. *Questionnaire.*

1	Where do you come from?
2	Do you feel uncomfortable with the number of people on the beach at present?
3	How many more/less than the number present do you feel the beach can accommodate without you feeling uncomfortable? -—-less than half -—-half -—-present number -—-2 × more -—-4 × more -—- >4 × more
4	What would your reaction be if the beach got overcrowded? -—-Stay -—-Move to a less dense spot/edge -—-Go to another beach -—-Go home -—-Other

1991, when the pier at Hobie Beach was being built. Thus the current surface area of Hobie Beach had to be measured *in situ,* since this beach had subsequently increased in size due to sand deposition south of the pier. Beach surface area was measured from the foredunes (or the wall at Hobie Beach) down to the spring low tide mark. The surface area at spring low tide was taken to be the average for the beach and shallow surf zone (where bathers were counted) at low and high tide, assuming that the surface area at spring low tide would include the shallow surf zone at high tide and compensate for the loss of area on the beach as the tide rose. It must be emphasised that these surface areas were conservative estimates and that bathers were sometimes observed in deeper water than the shallow surf zone.

Contingency tables were used to determine differences in responses between the three beaches, between the 2 public holidays, between the sexes and between the responses of local visitors and visitors from outside Port Elizabeth. Regression analysis was performed to test for relationships between the total number of people on a beach and the percentage of people that felt that a beach was overcrowded at the time of interview. A one-way analysis of variance (ANOVA) was used to test for differences in hourly abundance, observed visitor density, half-hourly percentages of visitors wanting less, the same number or more people on the beach between the three beaches, and to test for differences between the two public holidays on the same beach. Where necessary, square root or log-transformation was used to normalise data before analyses. The *a posteriori* multiple test of means of Least Significant Difference was used to highlight which beaches differed in the variable tested.

Since New Year's Day is traditionally the most popular day of the year for beach going in S.A., and beaches may become overcrowded on this day, respondents' perceptions of overcrowding on 1 January were taken as standard for estimating the SCC of the study beaches. Respondents wanting the same number of visitors on the beach at the time of interview (Table 1, Question 4) were assumed to feel comfortable with the visitor abundance and density at that time. These responses were used to give an indication of maximum densities tolerated on the beach over time.

As recommended by BROTHERTON (1973), SCC was given as a range rather than one value. SCC was expressed in terms of visitor abundance for a particular beach or in terms of visitor density.The abundance SCC (ASCC) for each study beach was defined as the visitor numbers at the times when the highest and second highest percentages of people indicated that they felt comfortable with the number of visitors on the beach:

$$\text{Maximum ASCC} = \text{VA1}$$
$$\text{Minimum ASCC} = \text{VA2}$$

where VA1 = the visitor abundance at the time when the highest percentage respondents were comfortable with the number of people on the beach during the period plus-minus 4 hrs from the peak of abundance, VA2 = the visitor abundance at the time when the second highest percentage respondents were comfortable with the number of people on the beach during the period plus-minus 4 hrs from the peak of abundance.

In order to compare SCC for different sized beaches, the density SCC (DSCC) was defined in terms of visitor density. Because patchy distribution of visitors on the beaches resulted in areas with high and low visitor densities, we distinguished, as in the case of visitor densities, between a beach and patch density SCC. The beach density SCC (BDSCC) was the density SCC if visitors were evenly distributed on the beach. It was calculated from abundance SCC and defined as:

$$\text{Beach DSCC (persons per 100 m}^2) = \text{ASCC/beach surface area (m}^2) \times 100$$

or

$$= \text{(VA1 to VA2)/beach surface area (m}^2) \times 100$$

The patch density SCC (PDSCC) was defined as the mean number of visitors per 10 × 10 m sampling block observed by the interviewers at the points in time when the highest and second highest percentage of respondents said that they wanted the same number of people on the beach. Hence:

$$\text{Patch DSCC} = \text{MD1 to MD2}$$

where MD1 = the mean patch visitor density (persons/100 m^2) at the time when the highest percentage respondents were comfortable with the number of people on the beach during the period plus-minus 4 hrs from the peak of abundance, and MD2 = the mean patch visitor density at the time when the second highest percentage respondents were comfortable with the number of people on the beach during the period plus-minus 4 hrs from the peak of abundance.

Maximum visitor density observed was the highest number of visitors observed by any interviewer in a 10 × 10 m block on a particular beach.

RESULTS

Joorst Park received the highest numbers of visitors on both holidays (Figure 2), whereas Hobie Beach, the smallest of the three beaches, received the lowest number of visitors, yet showed the highest mean beach and patch visitor densities on both days and the highest maximum patch visitor density (40 individuals per 100 m^2) recorded on any of the beaches during the study (Table 2). The beach visitor densities differed markedly from the patch visitor densities on all beaches (Table 2). King's Beach and Joorst Park received more visitors on New Year's Day than on 26 Dec. with higher beach visitor densities on the former day (Table 3). However, no

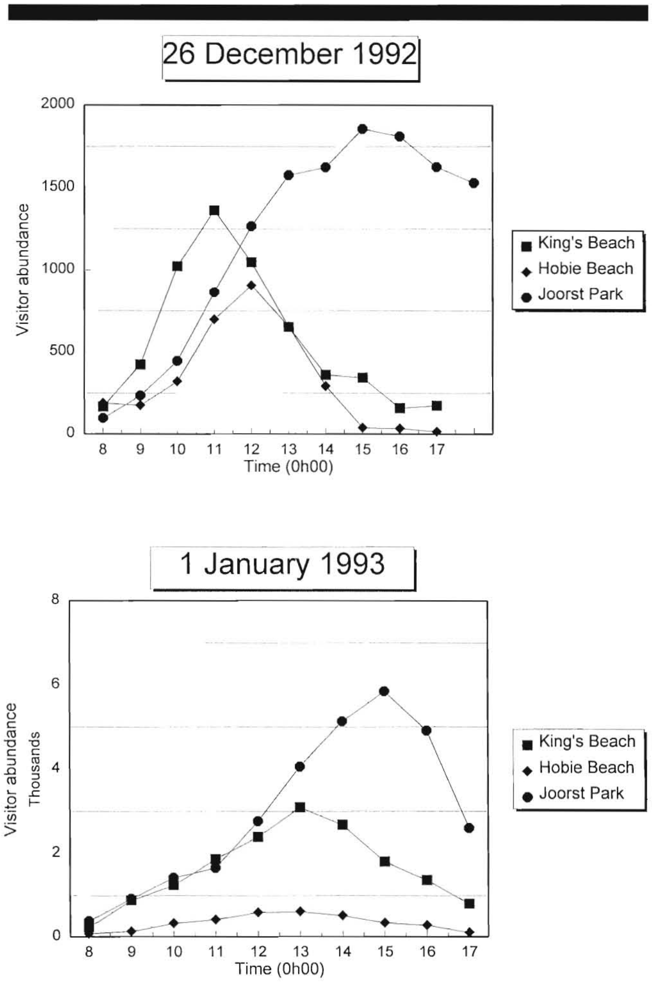

Figure 2. Numbers of people on three P.E. beaches on 26 December 1992 and 1 January 1993

Table 2. *Mean and maximum half-hourly visitor abundances, mean and maximum (in parentheses) visitor densities (per 100 m^2) on the three beaches on 26 Dec and New Year's Day.*

Beach	Mean Visitor Abundance ± SD	Maximum Visitor Abundance	Theoretical Mean Density ± SD & (max)	Observed Mean Density ± SD & (max)
	26 December 1992			
King's Beach	573 ± 396[a]	1,362	0.52 ± 0.4[a] (1.24)	11.8 ± 3.7 (17)
Joorst Park	1,242 ± 522[b]	1,855	1.35 ± 0.7[a] (2.0)	16.6 ± 8.2 (37)
Hobie Beach	331 ± 287[a]	612	3.32 ± 2.9[b] (9.1)	23.1 ± 8.4 (37)
F statistic (ANOVA) for columns*	F = 21.8, d.f = 2,58 p = 0		F = 6.8 d.f. = 2,29 p = 0.004	F = 8.55 d.f = 2,45 p = 0.007
	1 January 1993			
King's Beach	1,582 ± 898[a]	3,092	1.48 ± 0.8[a] (2.8)	11.9 ± 2.9 (32)
Joorst Park	2,903 ± 1,842[b]	5,850	3.2 ± 2.0[b] (6.4)	14.3 ± 4.6 (36)
Hobie Beach	332 ± 186[c]	612	3.37 ± 1.9[b] (6.1)	15.9 ± 7.3 (40)
F statistic (ANOVA) for columns*	F = 22.3, d.f = 2,58, p = 0		F = 3.73 d.f. = 2,27 p = 0.04	F = 2.14 d.f. = 2,54 p = 0.13

* a,b,c signify significant differences for columns

difference in patch visitor densities was found between the two days, demonstrating that people have a specific 'aggregation need', no matter how much space is left unoccupied. On Hobie Beach, in contrast, the beach visitor density did not differ between the two days, whereas the patch visitor density was higher on 26 December, during the volley ball tournament, than on New Year's Day (Table 2). The visitor abundance peaks at Joorst Park occurred later (15h00) than at the other two beaches on both days (Figure 2). At King's Beach the visitor abundance peak on New Year's Day occurred later than on 26 December.

The percentage of visitors requesting fewer people (y) on the beach was significantly correlated with half-hourly visitor abundances (x) on all beaches, with the highest percentage of variability explained on the most densely populated Hobie beach:

King's Beach:

$$y = -0.82 + 0.006x,$$
$$r = 0.53,\ R^2 = 28\%\ (F = 5.4,\ d.f. = 1,18,\ p = 0.03)$$

Joorst Park:

$$y = 4.42 + 0.003x,$$
$$r = 0.51,\ R^2 = 26\%\ (F = 6.2,\ d.f. = 1,14,\ p = 0.02)$$

Hobie Beach:

$$y = 3.17 + 0.01x,$$
$$r = 0.71,\ R^2 = 51\%\ (F = 14.1,\ d.f. = 1,14,\ p = 0.002).$$

The majority of respondents on all three beaches on both days felt that the beaches could accommodate more people (Table 3).The highest percentage of respondents that wanted fewer or the same number of people on all three beaches on 26 December was recorded on Hobie Beach, corresponding to the high patch visitor densities recorded on this beach (Table 2). Since there was no difference in patch visitor density between beaches on New Year's Day (Table 2), no significant differences occurred between beaches in the percentage respondents wanting fewer people (Table 3). The highest percentage of respondents wanting more people on the beaches was recorded on King's Beach. A higher percentage of respondents wanting more people on the beach were present on days when visitor density was relatively low and vice versa.

Hobie Beach received the highest percentage of visitors from outside Port Elizabeth (53% vs. 15% for King's Beach and 6% for Joorst Park) because of the attraction of the pier

Table 3. *Comparison of mean percentages (± SD) of respondents wanting fewer, the same number or more people on the beach they were interviewed.*

Beach	% Less (± SD)	% Same (± SD)	% More (± S)	F Statistics (ANOVA) for Rows**
		26 December 1992		
King's Beach	2.7 ± 5 a,1	13.1 ± 9.6 a,2	84 ± 11 a,3	F = 328.7, d.f. = 2,42, p = 0
Joorst Park	3.8 ± 3.8 a,1	21.5 ± 10 a,2	71 ± 16 b,3	F = 127.8, d.f. = 2,54, p = 0
Hobie Beach	8.8 ± 8.1 b,1	41 ± 12.7 b,2	50.2 ± 15.4 c,2	F = 39.8, d.f. = 2,39, p = 0
F statistic (ANOVA) for columns*	F = 3.92, d.f. = 2,41 p = 0.002	F = 25.0, d.f. = 2.41 p = 0	F = 18.5, d.f. = 2,45 p = 0	
		1 January 1993		
Beach	% Less (± SD)	% Same (± SD)	% More (± S)	F Statistics (ANOVA) for Rows**
King's Beach	11.9 ± 11.9 a1	23.4 ± 11.5 a2	61.8 ± 17.4 a3	F = 77.0, d.f. = 2,57, p = 0
Joorst Park	14.3 ± 12.5 a1	22.8 ± 10.8 a1	62.9 ± 18.4 a2	F = 62.9, d.f. = 2,57, p = 0
Hobie Beach	8.1 ± 9.4 b1	19.4 ± 17.7 b2	72.5 ± 20.3 b3	F = 83.1, d.f. = 2,57, p = 0
F statistic (ANOVA) for columns*	F = 2.1 d.f. = 2.61 p = 0.13	F = 0.46 d.f. = 2,61 p = 0.6	F = 1.08 d.f. = 2,61 p = 0.3	

* a,b,c signify beaches with different means (i.e. P < 0.05, LSD)
** 1,2,3 signify responses with different means (i.e. P < 0.05, LSD)

and beach front restaurants and the safety of the beach for bathing and boat launching. No significant difference was found between the percentage of local respondents and those from outside Port Elizabeth in the percentage wanting fewer or more people on any of the beaches (Table 4). Neither was there a gender difference in the respondents wanting fewer people on any of the beaches.

The highest percentage of respondents wanting fewer people on the beach did not always correspond to the times when the highest visitor abundances occurred (Figures 3–5). The two highest percentages of respondents feeling comfortable with the visitor abundance at time of interview on King's Beach (*i.e.* content with the number but not wanting more people on the beach as were present), occurred just after the peak hour at 13h30 and 14h30, when visitor abundance was 2 900 and 2 300, respectively (Figure 3). For Joorst Park the highest percentages of respondents feeling comfortable with the visitor abundance occurred at 11h30 and 15h00, when the respective visitor abundances were 2 100 and 5 800 individuals (Figure 4). At Hobie Beach the highest percentages of respondents feeling comfortable with visitor numbers were interviewed at 14h00 and 15h00, when visitor abundances were 350 and 500, respectively (Figure 5). These abundances are taken as an indication of the Beach Abundance SCC of the three beaches.

The beach density SCC values for the beaches were derived from the above values for abundance SCC. With a surface area of 110 000 m^2 the beach density SCC for King's Beach was estimated to be approximately 2.1–2.6 persons/100 m^2 (Table 5). Similarly the beach density SCC for Joorst Park was estimated at 2.3–6.3 individuals/100 m^2 and 3.5–5.0 persons/100 m^2 for Hobie Beach.The mean beach density SCC for all three study beaches was 3.6 persons/100m^2. The patch density SCC values were more than three times higher than the beach density SCC values, confirming the visually assessed patchy distribution of visitors. Based on the visitor densities in the patches, the surface area per person was smallest on the most developed Hobie Beach and largest at Joorst Park, the least developed beach.

Considering respondents that wanted more people on King's Beach and Joorst Park at the time of interview, the majority stated that they would stay on the beach or move to the edge when the beach became overcrowded (Table 6), whereas similar percentages of respondents on Hobie Beach would either stay or go to another beach. Considering only those respondents that wanted fewer or the same number of people on the beach at the time of interview, the majority (73% on King's Beach, 67% at Joorst Park and 75% on Hobie Beach) said that they would leave the beach, either to go home or to another beach, when the beach became too crowded for their opinion.

DISCUSSION

As a result of territorial spacing, crowding perception, and thus social carrying capacity, depends on many characteristics related to the individual, such as personality type, sex, cultural and occupational background (Edney and Jordan-Edney, 1974). Moreover, crowding tolerance is higher in recreational situations, *i.e.*, crowding is perceived later (at higher densities), than under working conditions (Cohen *et al.*, 1975), possibly because people are under lower levels of stress and under no obligation to perform productive tasks when recreating.

However, factors external to the individual are also playing a role in regulating social carrying capacity. For example, patch density SCC was higher on more developed beaches, *i.e.* King's Beach and Hobie Beach, than on the less developed Joorst Park (Table 5). Moreover, the highest patch visitor densities were observed on the smallest beach, *i.e.* Hobie

Table 4. *Results of statistical tests done on numbers, densities and perceptions of respondents.*

Null Hypotheses Tested	Statistical Test	Result
1. Visitor abundance on King's Beach on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 20.1 d.f. = 1,38 p = 0.001
2. Visitor abundance at Joorst Park on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 14.1 d.f. = 1,38 p = 0
3. Beach visitor density on King's Beach on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 13.2 d.f. = 1,19 p = 0.002
4. Beach visitor density at Joorst Park on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 8.6 d.f = 1,18 p = 0.009
5. Beach visitor density at Hobie Beach on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 0.002 d.f = 1,19 p = 0.9
6. Patch visitor density on King's Beach on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 0.021 d.f. = 1,32 p = 0.9
7. Patch visitor density on Joorst Park on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 2.1 d.f = 1,32 p = 0.16
8. Patch visitor density on Hobie Beach on 26 Dec. and 1 Jan. 1993 are similar	ANOVA	F = 7.03 d.f. = 1,32 p = 0.01
9. Times of visitor abundance peaks on the three beaches on 26 Dec. 1992 are the same	ANOVA	F = 12.6 d.f = 2,12 p = 0.008
10. Times of visitor abundance peaks on the three beaches on 1 Jan. 1993 are the same	ANOVA	F = 10.1 d.f. = 2,12 p = 0.01
11. Times of visitor abundance peaks are the same for 26 Dec. 1992 and 1 Jan. 1993	ANOVA	F = 19.2 d.f = 1,8 p = 0.002
12. Response (wanting fewer or more people on the beach) between local visitors and those from outside Port Elizabeth on King's Beach was the same	2 × 2 Contingency table	χ^2 = 0.28 d.f. = 1 p = 0.6
13. Response between local visitors and those from outside Port Elizabeth on Joorst Park was the same	2 × 2 Contingency table	χ^2 = 0.21 d.f. = 1 p = 0.65
14. Response between local visitors and those from outside Port Elizabeth on Hobie Beach was the same	2 × 2 Contingency table	χ^2 = 0 d.f. = 1 p = 1
15. There was no gender difference in respondents wanting less people on any of the beaches	2 × 3 Contingency table	χ^2 = 0.2 d.f. = 2 p = 0.8

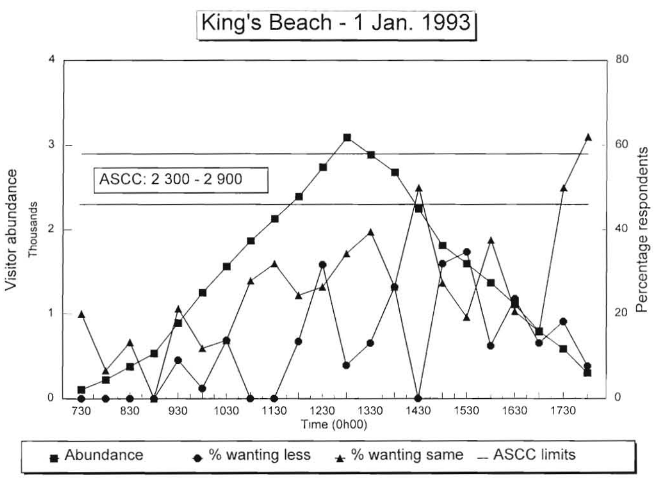

Figure 3. Hourly total numbers (left vertical axis), % respondents wanting fewer and % respondents wanting the same number of people on King's Beach on 1 January 1993 (right vertical axis) Upper and lower limits of ASCC are represented as horizontal lines.

Beach, during a volley ball tournament on 26 December. This beach also showed the highest SCC as determined on New Year's Day, even when no sport event took place. These facts clearly demonstrate that not only facilities but also crowd-attracting activities influence visitor crowding perceptions, enhancing social carrying capacity on sandy beaches. In developing countries such as South Africa, organized activities can be used to occupy people and provide a pleasant recreational experience on crowded beaches without having to invest in additional (expensive) facilities.

Other external factors besides facilities also seem to influence social carrying capacity. The highest percentages of respondents wanting more people on the beach were recorded

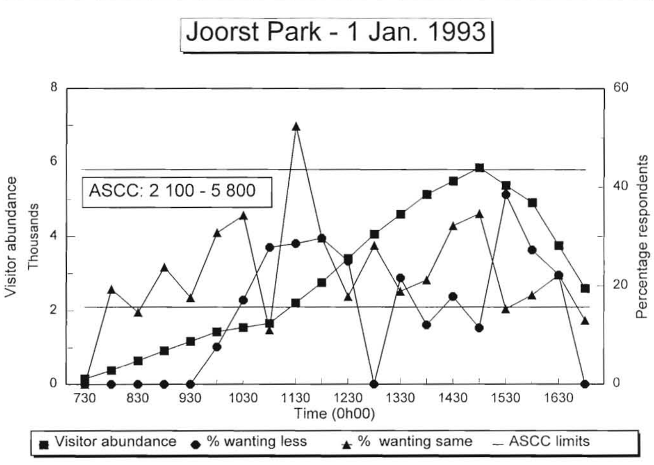

Figure 4. Hourly total numbers (left vertical axis), % respondents wanting fewer and % respondents wanting the same number of people on Joorst Park on 1 January 1993 (right vertical axis) Upper and lower limits of ASCC are represented as horizontal lines.

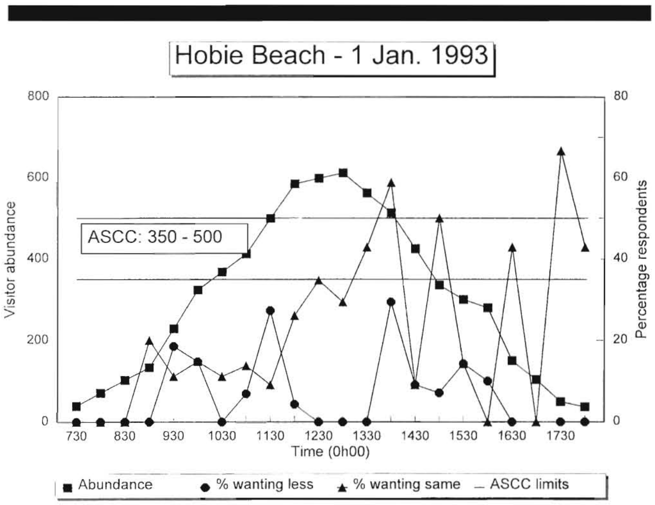

Figure 5. Hourly total numbers (left vertical axis), % respondents wanting fewer and % respondents wanting the same number of people on Hobie Beach on 1 January 1993 (right vertical axis) Upper and lower limits of ASCC are represented as horizontal lines.

Table 5. *Surface area, abundance SCC (ASCC), beach density SCC (BDSCC), patch density SCC (PDSCC) and surface area per person on three study beaches at times when the highest and second highest percentage of visitors felt comfortable with the number of people on the beach within plus-minus 4 h of the peak of abundance on 1 Jan. 1933 (See text for explanation).*

Attribute	King's Beach	Joorst Park	Hobie Beach
Surface area (m^2)	110,000	92,000	10,000
ASCC (visitor numbers)	2,300–2,900	2,100–5,800	350–500
BDSCC* (persons/100 m^2)	2.1–2.6	2.3–6.3	3.5–5.0
PDSCC (persons/100 m^2)	11–18	9–16	11–29
Mean PDSCC (persons/100 m^2)	14.5	12.5	20
Surface area per visitor (m^2/person)§	5.6–9	6.3–11	3.4–9
Mean surface area per visitor (m^2/person)§	7	8	5

*If visitors were evenly distributed over the whole beach
§Based on PDSCC

on the largest beaches, *i.e.* King's Beach and Joorst Park, suggesting that they are seldom perceived to be overcrowded, even during times of peak abundance. Also, at Joorst Park group size was found to be significantly larger (DE RUYCK *et al.*, unpublished data) and preferred intergroup spacing closer (DE RUYCK *et al.*, 1995) than at Kings Beach and Hobie Beach. Thus, larger and more evenly spaced groups on the beach accounted for the larger surface area utilised on this spacious beach. Our results thus support the idea that territorial spacing decreased as group size increased (EDNEY and JORDAN-EDNEY, 1974). Hence, beach size and group size seem to also enhance social carrying capacity.

CHAPMAN (1989), MORGAN *et al.* (1993) and DE RUYCK *et al.*, (1995) demonstrated that visitors' choice of beach is not random and that individual expectations of an ideal beach differ amongst visitors. Those that go to the beach for a social experience prefer developed beaches with crowds and plenty of activity, whereas at the other extreme, those beach visitors that focus on experiencing 'nature' prefer undeveloped beaches with natural beauty, peace and quiet (MORGAN *et al.*, 1993; DE RUYCK *et al.*, 1995; DE RUYCK *et al.*, unpublished data). These two types of beach users may be referred to as 'gregarious' vs 'individualistic' types respectively. Between these extremes there is much variation in beach experience expectations. The more developed a beach, the more popular it is with the gregarious type. This explains why crowding tolerance and SCC is higher on developed beaches such as Hobie and King's Beach than on less developed ones such as Joorst Park (this study) and Sardinia Bay (DE RUYCK *et al.*, 1995) which are visited for their natural beauty. Undeveloped beaches have a lower SCC because they receive a larger percentage of individualistic type visitors (DE RUYCK *et al.*, 1995) who feel overcrowded at lower user densities.

Patchy distribution of visitors, generally around facilities and entrance points, was obvious even on the larger beaches during the survey and was further statistically confirmed, *i.e.* mean patch densities were higher than beach densities (Table 2). This strengthens the theory that there is a range of preferred densities within which different types of people feel comfortable. The individualistic type will probably move further away when feeling overcrowded, creating even or random patterns of distribution, while the gregarious ones will move closer together when the beach is relatively empty, creating patchy patterns of distribution. Similarly, the observation that respondents wanted more people on the beach on days when mean visitor density was relatively low and vice versa suggests that visitors, depending on the personality type, have a preference for a specific range of visitor densities. Hence gregarious and individualistic types will feel uncomfortable on desolate and overcrowded beaches respectively. EDNEY's (1977) theory of limited conceptualization suggests that there is a series of (crowding) norms, with upper and lower thresholds, which should not be violated for the individual to function normally and feel comfortable. HEBERLEIN (1977) also mentions that appropriate levels of human density is essentially a normative concept, *i.e.*, crowding perception depends on what the person is used to or expects at a site.

Table 6. *Reaction to overcrowding on King's Beach (KB), Joorst Park (JP), and Hobie Beach (HB). Percentages of respondents interviewed on each beach are given in parentheses.**

Reaction to Overcrowding	King's Beach n = 644	Joorst Park n = 567	Hobie Beach n = 300
Go home	182 (28%)	114 (20%)	66 (23%)
Go to other beach	111 (17%)	71 (13%)	96 (32%)
Stay/move to less dense spot	329 (51%)	387 (68%)	93 (2%)
Other	9 (1%)		
χ^2 statistic between groups	χ^2 = 18.8, d.f = 2, p = 0	χ^2 = 64, d.f. = 2, p = 0	χ^2 = 1.82, d.f = 2, p = 0.39

*Some respondents did not answer; some said that they would either go home or to another beach

The reaction to overcrowding of the majority of respondents who wanted fewer or the same number of people on the beach at the time of interview was to leave the beach. This is expected because they were close to or already feeling uncomfortable. However, amongst respondents wanting more people on the beach at the time of interview, a significant difference in reaction to overcrowding between beaches was found. This behaviour may also be related to the size of the beach. On the smaller Hobie Beach, similar proportions of respondents indicated that they would stay or go away because most of the space on this beach was occupied most of the time. By contrast, most respondents on the large beaches (King's Beach and Joorst Park) were prepared to stay on the beach or move to the edge and not go away when it became overcrowded, since empty space was still available at time of interview. This supports the contention that social carrying capacity is largely self-regulating (BROTHERTON, 1973; HEBERLEIN, 1977) on open and non-access limited recreational areas. It should be kept in mind, however, that time of interview may be important since gathering opinions in a crowded situation may be biased in that the majority of the people present at the time may be more tolerant of crowds than the average person (BROTHERTON, 1973).

SCC is expected to change not only with time of year (*e.g.* seasons and more crowded on public holidays vs normal days) but also with time of day since persons wanting different beach experiences will visit the beach at different times of day (BROTHERTON, 1973). The individualistic type visitor is expected to arrive early in the morning and/or near sunset and will presumably avoid days and times of day when the numbers of people present make them feel uncomfortable. Thus, SCC derived from users' perceptions on the same beach will be lower if measured in the morning/evening than at midday when the gregarious visitors are in the majority. These predictions are fully supported by our results: the highest percentage of respondents feeling comfortable with the amount of people on the beach were found in the late afternoon on the developed Kings Beach and Hobie Beach, when only less than 5 percent of the day visitors were present (Figures 3–5).

In our study, the mean patch density SCC found for the three beaches here studied ranged from 13 to 20 persons per 100 m^2 (average = 16 persons per 100 m^2 (= 6.3 m^2/person). This is higher than the density standards set by most researchers and recreation authorities in other countries (Table 7). One should be cautious when comparing these results, since the previous studies did not clarify whether patch or beach density was used to set their standards. For comparative purposes, future studies should differentiate between patch and beach densities. Furthermore, we suggest that patch density be adopted as the estimator of SCC for two reasons: a) It reflects the crowding conditions in the immediate vicinity of the visitors, and b) can be used to compare crowding conditions on beaches of different sizes.

Because of its dynamic nature, social carrying capacity estimates should be defined as a range of values with minimum and maximum thresholds, rather than one fixed value (BROTHERTON, 1973). Furthermore, the SCC of a beach and the frequency with which it is reached during the year can

Table 7. *Average standards of recreational carrying capacity suggested for beaches.*

Average Density		
Surface Area (m^2) per Person)	Persons per 100 m^2	Reference
5	20	ANDRIC *et al.*, 1962 in PEARCE, 1981 (P37)
9.2*	11	ORRRC, 1963
9.2*	11	FLORIDA RECREATION & PARK ASSOCIATION, 1975
8	13	BAUD-BOVY & LAWSON, 1977
14	7	URBAN LAND INSTITUTE, 1981
10	10	AN FORAS FORBATHA, 1973
15	7	SOWMAN, 1987a
6.3[a]	16[a]	This study
25[b]	4[b]	(mean for 3 beaches)

*Converted from square foot per person
[a]Estimated from mean patch density SCC (PDSCC) for 3 beaches
[b]Estimated from mean patch density SCC (BDSCC) for 3 beaches

be a useful tool for beach managers and city planners as an indication of the need for more facilities or developing more beaches. Once the SCC standard is determined on the most popular day/s of the year, the visitor abundance and patch density can be monitored throughout the year on potentially crowded days. If the user abundance and patch density on a popular beach, such as Hobie Beach, frequently reaches or exceeds the SCC level throughout the year, the need to expand existing facilities or develop another beach close by is indicated to relieve the excessive recreational pressure on Hobie Beach. Since building new facilities is expensive, a cheaper alternative would be to organize social activities, *i.e.* sport tournaments, aerobics or music shows which can temporarily increase the SCC of popular beaches and provide pleasant distraction for the gregarious visitor type.

It must be noted that ecological carrying capacity of a beach, however, may be exceeded before social carrying capacity is reached (HEBERLEIN, 1977; SOWMAN, 1987b). Thus, both social and ecological carrying capacity should be estimated and thresholds established to determine which beaches should be developed and which should not. Beaches close to the tourist centre will have the highest SCC and will already be impacted, thus their development could be maximised for human use. Pristine beaches will have the lowest SCC and should not be developed in order to preserve their natural beauty and ecologic equilibrium. Development of beaches between these extremes should be dictated by their scientifically defined social and ecological carrying capacity thresholds.

CONCLUSION

Crowding tolerance, and therefore social carrying capacity, on beaches is enhanced by external factors such as recreational facilities and crowd-attracting activities and influenced by beach and visitor group size. Although social carrying capacity is ultimately set by each visitor's individual perception and opinion, beach planners, developers and ecologists should use it in conjunction with ecological carrying capacity as a tool to determine which beaches should be sacrificed for maximal human use and development.

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LITERATURE CITED

AN FORAS FORBARTHA, 1973. Brittas bay: a planning and conservation study. *An Foras Forbartha* (Dublin).

BAUD-BOVY, M. and LAWSON, F., 1977. *Tourism and Recreation Development.* London: Architectural Press, 74p.

BOOTS, B.N., 1979. Population density, crowding and human behaviour. *Progress in Human Geography,* 3(1), 13–63.

BROTHERTON, D.I., 1973. The concept of carrying capacity of countryside recreation areas. *Recreation News Supplement,* 9, 6–11.

CHAPMAN, D.M., 1989.Human users and the beach/dune environment. *In*: CHAPMAN, D.M., (ed.), *Coastal dunes of New South Wales: Status and Management.* University of Sydney Coastal Studies Technical Report No. 89/3.

COHEN, J.L.; SLADEN, B., and BENNETT, B., 1975. The effects of situational variables on the judgement of crowding. *Sociometry,* 38, 273–281.

DE RUYCK, A.M.C.; SOARES, A.G., and MCLACHLAN, A. 1995. Factors influencing human beach choice on three South African beaches: a multivariate analysis. *Geojournal,* 36(4), 345–352.

EDNEY, J.J., 1977. Theories of human crowding: a review. *Environment and Planning,* A9, 1211–1232.

EDNEY, J.J. and JORDAN-EDNEY, N.L., 1974. Territorial spacing on a beach. *Sociometry,* 37(1), 92–104.

FLORIDA RECREATION AND PARK ASSOCIATION, 1975. Criteria for leisure facilities. *In*: *Florida Design Standards and Quantities for Parks, Recreation and Open Space.* Florida Planning and Zoning Association, 46p.

HEBERLEIN, T.A., 1977. Density, crowding and satisfaction: sociological studies for determining carrying capacitites. *In*: *Proceedings: River Recreation Management and Research Symposium, January 24–27,* (Minneapolis). USDA Forest Service Technology Report NC, pp. 67–76.

HEBERLEIN, T.A. and SHELBY, B., 1977. Carrying capacity, values and the satisfaction model: A reply to Greist. *Journal of Leisure Research,* 9(2), 142–148.

HERRICK, T.A. and MCDONALD, C.D., 1992. Factors affecting overall satisfaction with a river recreation experience. *Environmental Management,* 16(2), 243–247.

JAAKSON, R.; BUSZYNSKI, M.D., and BOTTING, D., 1976. Carrying capacity and lake recreation planning. *Town Planning Review,* 4, 359–373.

MILLER, M.L. and AUYONG, J., 1991. Coastal zone tourism—a potent force affecting environment and society. *Marine Policy,* 75–99.

MORGAN, M.L.; JONES, T.C., and WILLIAMS, A.T., 1993. Opinions and perceptions of England and Wales Heritage Coast beach users: some management implications from the Glamorgan heritage Coast, Wales. *Journal of Coastal Research,* 9(4), 1083–1093.

ORRRC, 1963. Outdoor Recreation Resource Review Commission Report No. 4, 156p. Washington, D.C. U.S. Government Printing Office.

PEARCE, D.G., 1981. *Tourist Development.* London: Longman.

SOWMAN, M.R., 1987a. Environmental Evaluation of Townships and Resort Development Proposals in the Cape Coastal Zone—A Manual. University of Cape Town, South Africa: Environmental Evaluation Unit Research Report 6/87/19, Appendix 7.

SOWMAN, M.R., 1987b. A procedure for assesssing recreational carrying capacity of coastal resort areas. *Landscape and Urban Planning,* 14, 331–344.

SOWMAN, M.R. and FUGGLE, R.F., 1987. Assessing recreational carrying capacity: a case study of the Kromme River Estuary, South Africa. *Journal of Shoreline Management,* 3, 53–75.

THREINEN, W.C., 1964. An analysis of space demands for water and shore. *In*: *Transactions of the 29th North American Wildlife and Natural Resource Conference.* Washington, DC: Wildlife Management Institute.

URBAN LAND INSTITUTE, 1981. *Recreational development handbook.* Washington, DC. Urban Land Institute, Appendix M.

WILLIAMS, D.R., 1988. Great expectations and the limits to satisfaction: A review of recreation and consumer satisfaction research. *In*: *Outdoor Recreation Benchmark: Proceedings of the National Outdoor Recreation Forum.* Asheville, North Carolina: US Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, General Technical Report SE-52, pp. 422–438.