Recreational use of a rocky intertidal reef in Victoria: implications for ecological research and management

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Rocky intertidal reefs are an increasingly popular setting for recreational activities in Australia. As a result, managers need to better understand and quantify the visitation levels and recreational use of these areas to ensure the protection of intertidal marine communities. We surveyed the recreational use of a rocky intertidal reef at Sorrento, a popular summer holiday destination in Victoria. The section of the reef with greatest visitor access received the most visitors; regardless of whether it was school holidays or weekends during the school term. The most popular and potentially threatening activities included walking over beds of the fucoid alga, Hormosira banksii, followed by collecting biota and fossicking. Most activities were passive in nature and we theorise that many visitors are unaware of their contribution to local environmental impacts. We suggest that public education is an ideal management strategy to increase visitors' environmental awareness and teach visitors about low-impact behaviours. By performing recreational use surveys in conjunction with site specific ecological surveys of the impacts of recreational use, management agencies will be able to devise more effective strategies which will better protect rocky intertidal reef habitats in the future.

Keywords: environmental awareness, *Hormosira banksii,* management, recreational use, trampling

Coastal areas play an important social and cultural role for many Australians, with the natural values of such areas attracting many people to live or spend their holidays near the coast (Zann 1995). The importance of coastal areas is particularly apparent given that over 85 per cent of Australia's population lives within 50 kilometres of the coastline (ABS 2004a), and there is an increasing tendency for people to make their own 'sea change' by moving to the coast from metropolitan areas (ABS 2004b; Gurran et al. 2006). Along with the popularity of coastal areas, there has been an increased recognition of the value of these natural environments to provide opportunities for recreational activities (Zann 1995; Parks Victoria 2003; Wescott 2006). Of these areas, rocky intertidal reefs, which are accessible at low tide, have been highlighted as very popular recreational areas that are not being adequately protected from recreational use (Zann 1995; Wescott 2006). The importance of protecting rocky intertidal reef habitats has been highlighted by the detection of significant ecological impacts (Ghazanshahi et al. 1983; Fairweather 1991; Underwood 1993; Zann 1995; Keough & Quinn 2000).

The two largest threats to rocky intertidal reefs from recreational use around the world are the trampling on biota and collection of marine life (Castilla & Durán 1985; Fairweather 1991; Povey & Keough 1991; Keough et al. 1993; Underwood 1993; Addessi 1994; Keough & Quinn 1998). Trampling can cause variable changes to rocky intertidal communities, but generally fucoid algae (e.g. Hormosira banksii in Australia and New Zealand) are most susceptible (Povey & Keough 1991; King 1992; Keough & Quinn 1998; Schiel & Taylor 1999). Trampling causes a reduction in cover and frond length of fucoid algae, and recovery from intensive trampling can take many years (King 1992; Keough & Quinn 1998; Schiel & Taylor 1999; Benedetti-Cecchi et al. 2001; Cervin et al. 2005). The alteration of the canopy structure of fucoid algae can lead to indirect effects on the abundance and diversity of other plants and animals within the marine community (Povey & Keough 1991; Keough & Quinn 1998; Schiel & Taylor 1999; Benedetti-Cecchi et al. 2001; Cervin et al. 2005). The collection of marine invertebrates and algae for food or bait, though only by a small number of visitors to rocky intertidal reefs, can directly result in a substantial reduction in the abundance and average size of harvested species populations (Moreno et al. 1984; Castilla & Durán 1985; Hockey & Bosman 1986; Castilla & Bustamante 1989; Fairweather 1991; Keough et al. 1993; Keough & Quinn 2000). This also leads to indirect effects on other species and therefore results in changes in the overall community structure (Castilla & Durán 1985; Fairweather 1991; Underwood 1993; Lasiak & Field 1995).

Many visitors to rocky intertidal reefs are likely to be well intentioned when they engage in recreational activities; however, they may fail to realise the extent of

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their contribution to the impacts on the local environment (Kavallinis & Pizam 1994; Alessa et al. 2003; Priskin 2003). Although the environment has become a mainstream issue, and more of the world's population have become environmentally aware (Takala 1991; Howell & Laska 1992; Lothian 1994; Fransson & Gärling 1999), for many people this awareness has failed to translate into environmentally responsible behaviours (Heberlein & Black 1976; Van Liere & Dunlap 1981; Scott & Willits 1994; Fransson & Gärling 1999; Lothian 2002; Alessa et al. 2003; Priskin 2003). This is because there has not been a corresponding increase in knowledge about what appropriate behaviours will minimise environmental impacts (Scott & Willits 1994; Fransson & Gärling 1999; Lothian 2002).

A substantial amount of literature exists on the impacts of recreational activities on marine communities from rocky intertidal reefs along the south-eastern Australian coastline (Fairweather 1991; Povey & Keough 1991; King 1992; Keough et al. 1993; Keough & Quinn 1998; Arundel & Fairweather 2002). In comparison, relatively few studies have quantified the visitation levels and recreational activities on rocky intertidal reefs (but see Underwood & Kennelly 1990; Kingsford et al. 1991; Porter & Wescott 2004). In this study, we aimed to quantify the recreational use of an intertidal reef at Sorrento, which is one of central Victoria's most popular summer holiday destinations, to aid in the improvement of natural resource management.

We conducted an observational survey of visitors to the Sorrento rocky intertidal reef to investigate: whether there were more visitors to sections of the intertidal reef with high access compared to low access; how the pattern of visits changed in school holidays compared to school term time; whether the number of cars in the car park reflected the number of visitors to the most accessible section of the reef; what proportion of visitors were involved in different types of recreational activities, and where these occurred on the reef.

Methods

Study site

Sorrento is a popular holiday destination for residents from the Melbourne metropolitan area in Victoria, Australia. This is particularly the case during the summer months of December and January when Victoria's major school holidays occur. Sorrento is now considered the most accessible and popular ocean beach site in the Mornington Peninsula National Park, with estimates of over half a million people visiting it each year (Parks Victoria 1998; Zanon 2002). Europeans have been visiting the ocean beach and rocky intertidal reef at Sorrento in large numbers for over a century, with records of high visitation dating back to the 1870s (J. South, 2006, pers. comm., November). From the beginning of its popularity as a seaside resort, the Sorrento ocean beach and rocky intertidal reef have been managed to varying degrees in response to environmental and recreational issues. In 1933, the main rockpool on the rocky intertidal reef was substantially deepened and widened to allow for increased visitor use (in particular to dive into the rockpool) while minimising the risk of injury to visitors (J. South, 2006, pers. comm., November). In 1995, the rocky intertidal reef at Sorrento became part of the Mornington Peninsula National Park: a terrestrial park that extends to the low tide level, and is managed by Parks Victoria primarily for ecosystem conservation and recreation (Parks Victoria 1998). Current management of Sorrento rocky intertidal reef includes the provision of multiple interpretive signs, including a small sign depicting prohibition of shellfish collection at the main access point to the beach. Parks Victoria rangers also intermittently patrol the area for maintenance, and to monitor prohibited activities such as shellfish collection.

Observational survey of recreational use at Sorrento rocky intertidal reef

Observational surveys of visitors to Sorrento rocky intertidal reef and their activities were conducted throughout January and February 2006. Surveys were conducted at two 100 metre-wide sections of intertidal reef, which were referred to as the 'high access' and 'low access' sites (Figure 1). The high access site is located next to the main beach of Sorrento, and is easily accessed via stairs connected to the car park. The low access site is approximately 300 metres north-west of the high access site, and has substantially lower visitation due to its distance from the main access points to Sorrento ocean beach.

Sixteen surveys of visitors to both the high and low access sites were conducted over eight weeks. The first four weeks were school holiday time and the remaining four weeks were school term time. During each week, the high and low access sites were surveyed on one weekday and one weekend day. Surveys were conducted during daylight hours over a two hour period, one hour either side of the predicted low tide time. All surveys were conducted on days where the predicted low tide was between 0 – 0.4 metres above mean sea level, which ensured that the intertidal reef was entirely exposed to

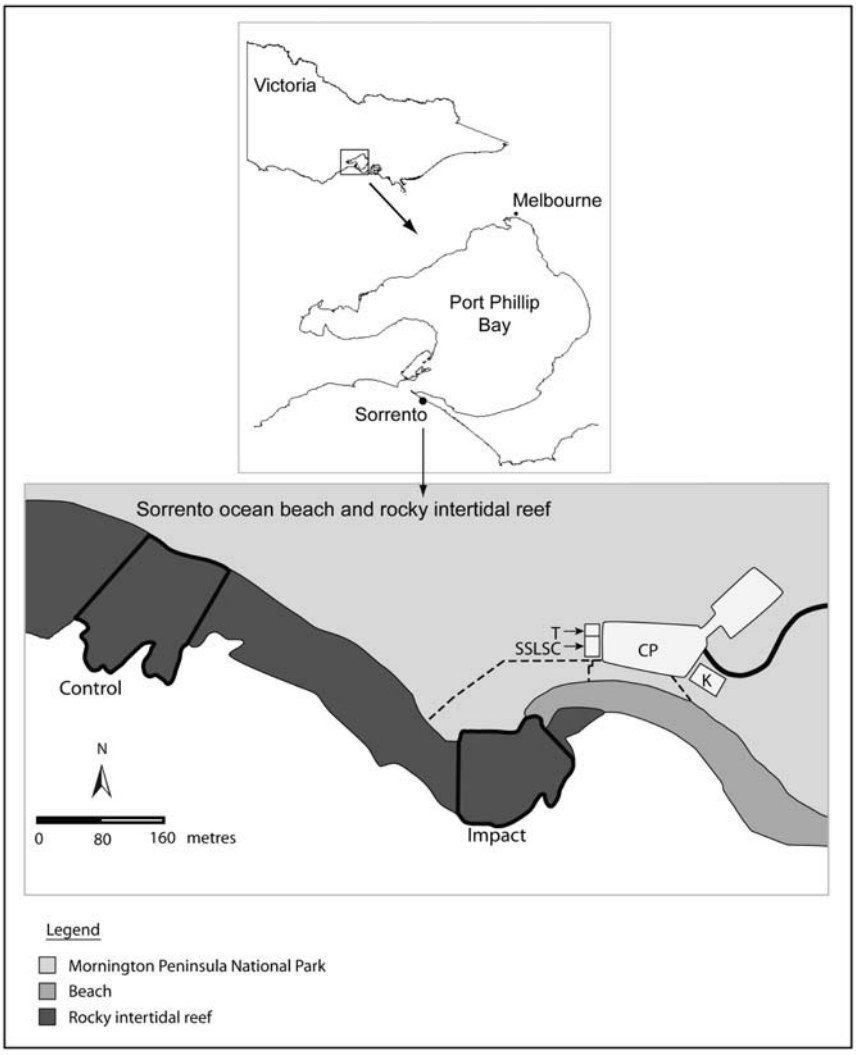

Figure 1 **Location of Sorrento rocky intertidal reef**

Note: Boundaries of the high access (centre point: 144°43'31", 38°20'48") and low access (centre point: 144°43'17", 38°20'41") sites are shown, along with the walking access points (dashed lines), main access road (solid line), car park (CP), kiosk (K), Sorrento Surf Life Saving Club (SSLSC) and a public toilet block (T).

recreational use. During each two hour survey, observations of human activities were made over four periods (each five minutes in duration, separated by thirty minutes, to ensure independence). During each observation period, each visitor and their first observed activity was recorded. Based on their physical appearance, children (under 16 years of age) and adults (those older than 16 years of age) were counted separately, as it was anticipated that these groups would be involved in different types of activities.

Visitor activity was classified into walking or rockpool activities based on a simple descriptor of their observed behaviour. Thus 'randomly walking' refers to visitors who were wandering over the intertidal rock platform; 'fossicking while walking' refers to visitors who were actively investigating the marine life of the intertidal platform without removing biota in the process; and 'walking along a path' refers to visitors who were walking on narrow sections of reef that were worn by high recreational use. These paths were usually distinguished by having little or no plant and animal life and, in some cases, the rock platform had been eroded from high levels of foot traffic. Visitors were also occasionally observed walking with their dogs; although this activity is prohibited after 9 am during the summer (Parks Victoria 1998). Rockpool activities included standing on the edge of or within a rockpool (often adults supervising children), or exploring the edge of a rockpool. Other rockpool activities included jumping into rockpools, swimming, snorkelling or body boarding. The only two exploitative activities observed at Sorrento were collecting invertebrates and algae, and fishing in a rockpool or off the reef edge.

Each visitor and their first observed activity was recorded within the different shore levels at the high access site. Shore levels were recorded as either high, mid or low, and were determined by the biological and physical characteristics of the intertidal reef. High shore was the section of reef higher in elevation than the rest of the reef platform and was characterised by the dominance of the snails, *Austrolittorina unifaciata* and *Afrolittorina praetermissa.* The mid shore made up a large area of the flat reef platform and was characterised by the dominance of the fucoid alga, *Hormosira banksii.* The low shore was the seaward edge of the flat reef platform and was characterised by the dominance of many species of algae (e.g. *Laurencia spp., Ulva spp., Cystophora spp*. and many filamentous red and green alga species).

In addition, the daily number of cars entering the Sorrento Ocean Beach car park was obtained from Parks Victoria (from entry fee records) for all of January and the weekends in February 2006. We used these data to investigate the relationship between daily car numbers

and the average number of visitors to the high access site over a five minute period.

Statistical analyses

Analysis of variance was used to test the difference in numbers of visitors engaged in different recreational activities between high and low access sites, school holidays and school term, and weekdays and weekends. The analysis was a factorial design with Site (high access or low access; fixed), Holiday (school holiday or school term; fixed) which was crossed with Site, and Week (weekday or weekend day; fixed) which was crossed with Holiday. For this analysis, the walking or rockpool activity grouping was applied. Analyses were run separately on the count of adults and children engaged in walking and rockpool activities. The four sets of observations (over five minute periods) recorded at the high and low access sites during each survey were used as replicates in this analysis, and these data were $\log_{10}(x+1)$ transformed to meet the assumptions of normality for the statistical analyses. Tukey post-hoc pairwise comparisons were carried out to assess which groups were significantly different when a significant interaction was detected through analysis of variance.

Linear regression was used to compare the daily number of cars in Sorrento car park with the average number of visitors observed at the high access site within a five minute observation period on each survey day. This analysis only included twelve days of survey data obtained during the school holidays (weekdays and weekends) and the school term (weekends only).

The proportion of visitors engaged in different walking and rockpool activities at the high and low access sites were compared using analysis of variance. Activity type was the single factor (fixed) used in these one way analysis of variance tests, and the response variable was proportion of visitors (adults and children combined) that were engaged in each activity during each replicate observation. This test requires at least one visitor to be present during a survey day in order to estimate the proportion of visitors engaged in each activity; therefore, if there were no visitors recorded during a survey day, these data were not included in the analysis.

The number of visitors associated with either walking or rockpool related activities was compared between the high, mid and low shore levels of the high access site. This was done using the data from twelve of the survey days. Data from the school term weekdays were excluded, due to very few visitors being observed at the high access site during this time. One way analysis of variance was used to test the difference in the total number of visitors engaged in either walking or rockpool activities between shore levels (high, mid and low; fixed) during each replicate observation time. A significant effect was detected for both tests, and Tukey post-hoc pairwise comparisons were carried out to assess which shore levels were significantly different to each other. All analyses were performed using the statistical package Systat 10.

Results

Visitation to Sorrento rocky intertidal reef

The maximum number of visitors observed within a single five minute observation period was 117 at the high access site on a weekend during the school holidays. In comparison, there was a maximum of 36 visitors at the low access site on one survey replicate on a weekday during the school holidays. However, at both sites there were five minute periods when no people were observed. Of the activities observed at the high and low access sites, most were passive with only a few visitors engaged in exploitative activities. The small number of people engaged in exploitative activities included 5 per cent of visitors fishing and no-one collecting at the low access site, and 0.2 per cent of visitors fishing and 0.2 per cent of visitors collecting at the high access site.

At both high and low access sites there were generally more adults engaged in walking activities, while more children were engaged in rockpool activities (Figure 2). The average number of children and adults engaged in walking and rockpool activities followed very similar patterns over the school holidays and school term and over weekdays and weekends (Table 1, Figure 2). Analysis of variance of adults and children engaged in walking and rockpool activities revealed some significant interactions between visitation levels at the high and low access sites, between school holidays and the school term, and between weekdays and weekend days. Pairwise comparisons revealed that significantly more adults engaged in rockpool activities and more children engaged in both walking and rockpool activities at the high access site compared to the low access site, both during the school holidays and in the school term (significant Site x Holiday interaction) (Table 1, Figure 2). There were also significantly more adults and children engaged in both walking and rockpool activities at the high access site compared to the low access site both during weekdays and the weekend (significant Site x Week interaction) (Table 1, Figure 2). Finally, there was no significant difference between the number of adults and children

Table 1 **Differences in numbers of adults and children engaged in walking and rockpool activities**

Source	df	Adults		Children	
		Walking	Rockpool	Walking	Rockpool
Site	1	< 0.001	< 0.001	< 0.001	< 0.001
Holiday	1	< 0.001	< 0.001	< 0.001	< 0.001
Week	1	< 0.001	0.060	0.001	< 0.001
Site x Holiday	1	0.617	0.002	< 0.001	< 0.001
Site x Week	1	0.008	< 0.001	< 0.001	< 0.001
Holiday x Week	1	< 0.001	< 0.001	< 0.001	0.017
Site x Holiday x Week	1	0.968	0.919	0.133	0.154
$MS_{Residual}$	120	0.101	0.080	0.098	0.107

Note: Analysis of variance was conducted on the number of visitors engaged in the different recreational activities which were $log_{10}(x+1)$ transformed. $MS_{Residual}$ values and degrees of freedom are provided to allow reconstruction of the full ANOVA table. Significant p-values are highlighted in bold. All main factors (Site, Holiday and Week) are uninterpretable due to the significant interactions detected for each test.

engaged in both walking and rockpool activities on weekdays compared to weekend days during the school holidays; however, there were significantly fewer visitors observed on weekdays compared to weekend days during the school term (significant Holiday x Week interaction) (Table 1, Figure 2). Further, pairwise comparisons for significant Holiday x Week interactions for all tests revealed that the number of weekend visits during school holidays and school term for adults and children engaged in walking and rockpool activities was not significantly different at the low access site. Finally, there was no significant difference between the number of adults and children engaged in both walking and rockpool activities on weekdays compared to weekends during the school holidays; however, significantly lower numbers of visitors were observed on weekdays compared to weekends during the school term (significant Holiday x Week interaction) (Table 1, Figure 2).

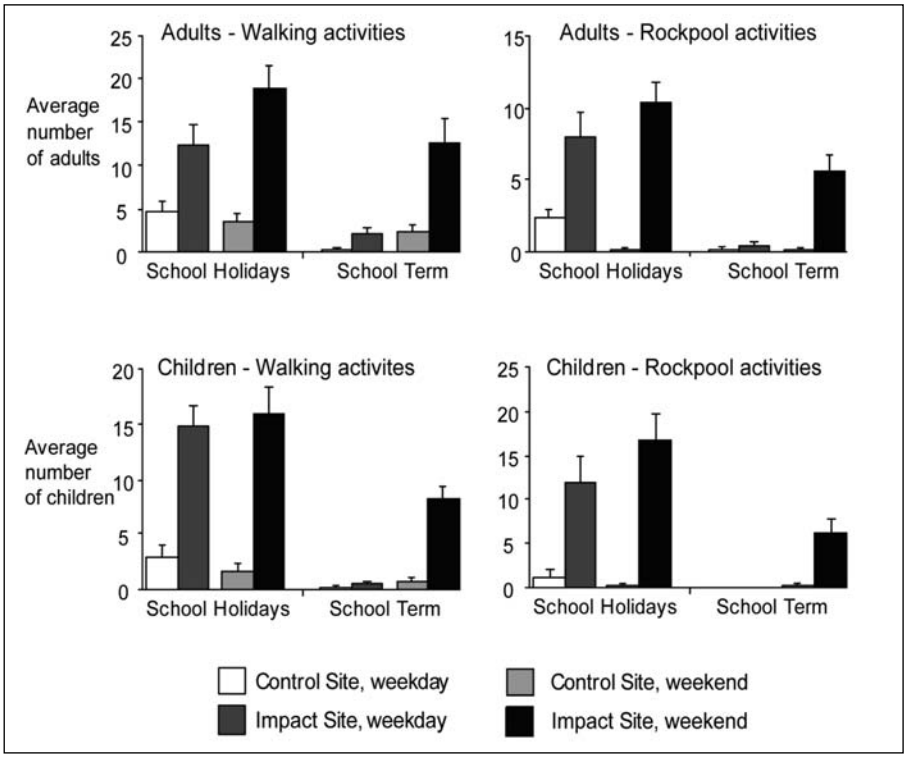

Figure 2 **Adults and children engaged in walking and rockpool activities**

Note: The average number (±s.e) of adults and children are shown at the high and low access sites, during the summer school holidays and the first school term and on weekdays and weekend days.

Throughout January and on weekends in February 2006, 9482 cars entered the Sorrento car park. The daily number of cars entering Sorrento car park and the average number of visitors at the high access site were significantly correlated (R^2=0.546, p=0.006) (Figure 3). This was a positive relationship, with the average number of visitors observed at the high access site increasing with an increased number of cars recorded for the day.

Recreational activities at Sorrento rocky intertidal reef

Of the walking activities at the high access site, the highest proportion of visitors was randomly walking over the intertidal platform (Table 2 and Figure 4). This was closely followed by visitors walking along a path and fossicking while walking. Few visitors were observed walking with dogs at the high access site; although some were observed there after 9am when it is prohibited (Parks Victoria 1998). A number of different activities were observed in association with the rockpools at the high access site, with the highest proportion of visitors standing on the edge of rockpools (often adults supervising children) (Figure 4). This was closely

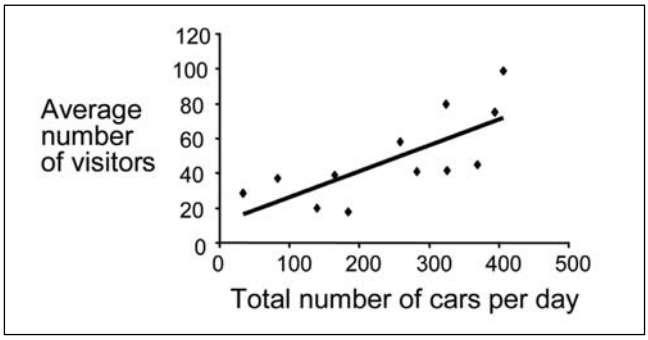

Figure 3 **The average number of visitors to the high access site versus the daily number of cars entering Sorrento car park**

followed by a high proportion of visitors observed swimming in rockpools and jumping into the main rockpool at the high access site from the rocky outcrop platform (often children) (Figure 4).

At the low access site, visitors engaged in walking activities were mostly randomly walking over the intertidal platform (Figure 4). A substantially lower proportion of visitors was observed walking along a 'path' and fossicking while walking. There were a number of rockpool activities observed at the low access site; however, there was no significant difference between these activities (Table 2 and Figure 4). The three rockpool activities which visitors were most often engaged in at the low access site were fishing (in rockpools near the platform edge or in the sea just off the platform), swimming, and standing in rockpools (Figure 4).

Table 2 **Differences in the proportion of visitors engaged in different types of walking and rockpool activities at the high and low access sites**

	F-ratio	p-value
High access site		
Walking activities	$F_{3,64}$=21.69	<0.001
Rockpool activities	$F_{8,117}$=54.95	<0.001
Low access site		
Walking activities	$F_{2,36}$=18.80	<0.001
Rockpool activities	$F_{5,48}$=1.83	0.126

For walking and rockpool activities at the high access site, there were significant differences between shore levels for the number of visitors engaged in walking activities ($F_{2,141}$= 72.47, p<0.001) and rockpool activities ($F_{2,141}$ = 61.323, p<0.001) (Figure 5). Pairwise comparisons revealed that there were significantly higher numbers of visitors engaged in walking activities and rock pool activities in the mid shore compared to both the high and low shore levels (Figure 5). In addition, 85 per cent of the visitors engaged in rockpool activities in the mid shore at the high access site were using the main rockpool, which is the deepest and largest rockpool. Some visitors were involved in rockpool activities in the high shore level (Figure 5). These people were using a high shore section of rock to jump into the main rockpool, which is located in the mid shore, next to the high section of rock.

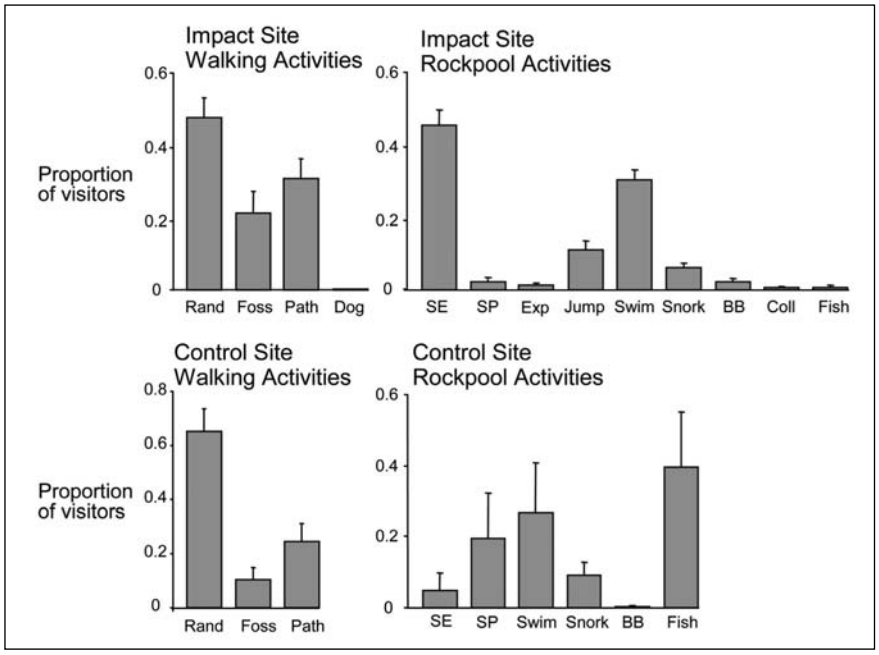

Figure 4 **The proportion of visitors engaged in different walking and rockpool activities at the high and low access sites**

Note: Average values are shown, with standard errors. Definition of abbreviations: Rand - randomly walking; Foss - fossicking while walking; Path - walking along a path; Dog - walking with a dog; SE - standing on the edge of a rockpool; SP - standing within a rockpool; Exp - exploring the edge of a rockpool; Jump - jumping into a rockpool; Swim - swimming in a rockpool; Snork - snorkelling in a rockpool; BB - body boarding in a rockpool; Coll - collecting in and around a rockpool; Fish - fishing in a rockpool or off reef edge.

Discussion

Visitation

This study revealed that more people visited the high access site compared to the low access site at Sorrento rocky intertidal reef. This supports Adessi's (1994) finding that there are generally greater numbers of people on intertidal

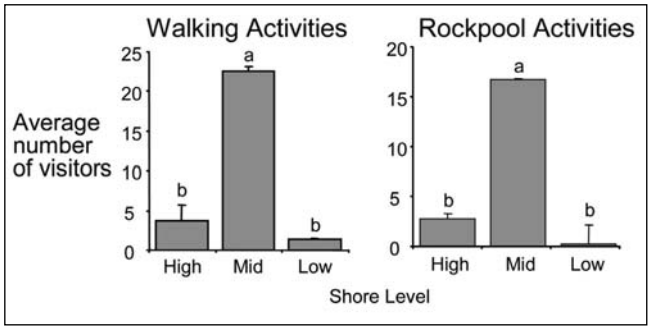

Figure 5 **The number of visitors engaged in walking or rockpool associated activities at the different shore levels at Sorrento's high access site**

Note: The average number of visitors and standard errors are shown for high, mid and low shore levels. Letters above each bar represent pairwise comparisons - where letters are different, shore levels are significantly different.

reefs closer to public access points. Anecdotal evidence suggests that visitors do not feel inclined to walk the extra distance to the low access site at Sorrento because they believe it is no different to the high access site. This spatial pattern of visitation is probably encouraged by Parks Victoria's signs which invite visits to the high access site access site, but highlight the dangers of accessing the intertidal reef beyond the low access site.

The number of people visiting the high and low access sites varied significantly over the survey period. During the school holidays, there were similar visitation levels on weekdays compared to weekends; however, there was significantly lower visitation on weekdays compared to weekends during the school term. In addition, visitation levels on weekends were significantly lower at the high access site during the school term compared to during the school holiday. This visitation pattern reflects the large increase in the summer population in towns surrounding Sorrento. Similar visitation patterns have been observed at intertidal reefs at Point Lonsdale and Bunurong Marine Protected Areas in Victoria that experience similar population increases over summer (King 1992; Porter & Wescott 2004).

There was a significant positive relationship between the number of cars in the car park and the number of visitors to the high access site each day. Although this relationship was significant, the daily number of cars entering Sorrento car park explained only 55 per cent of the variation in the average number of visitors at the high access site. Sorrento ocean beach is mainly accessed by people who drive into the car park, with few people accessing the area by foot. However, many people only visit the sandy beach and not the rocky intertidal reef, and as a result, the number of cars is not an accurate measure of visits to the intertidal reef.

Ecological implications of recreational activities

There were more adults than children engaged in walking activities at both the high and low access sites. All walking activities were considered passive, with most visitors either randomly walking over the platform or walking along paths in the mid shore of the high access site where there are extensive beds of *Hormosira banksii.* The greatest threat of trampling on rocky intertidal reefs is to *H. banksii* and associated biota (Povey & Keough 1991; King 1992; Keough & Quinn 1998; Schiel & Taylor 1999), and this has long been an issue of primary concern for Parks Victoria (Carey et al. 2007). On intertidal reefs near Sorrento, Povey and Keough (1991) have demonstrated that a single footstep can cause a reduction in 20 per cent of the biomass of an individual *H. banksii* plant, and increasing trampling levels to 75 footsteps caused up to 60 per cent reduction in biomass. The trampling levels used in experiments by Povey and Keough (1991) are similar to those seen in our survey, once extrapolated over low tide periods. There was a maximum of 57 people walking randomly and 30 people walking along paths where *H. banksii* is present within a five minute survey period at the high access site. With such detrimental levels of trampling, particularly along the narrow areas where paths exist, the recovery of *H. banksii* could be greater than 400 days (Povey & Keough 1991). This could lead to a 'press' disturbance, such as that demonstrated by Keough and Quinn (1998), where there is insufficient time to allow the complete recovery of *H. banksii* beds between the summers of each year. Although we have highlighted the potential impacts of trampling at Sorrento intertidal reef, many studies have demonstrated considerable spatial variation in the impact of trampling on *H. banksii* (Povey & Keough 1991; King 1992; Keough & Quinn 1998).

Another activity associated with walking was fossicking. Although fossicking does not involve the removal of biota, it can have impacts on marine communities particularly when boulders are overturned and not replaced in their original position (McGuinness 1987). However, when boulders are carefully replaced in their original position, plant and animal communities living under boulders can rapidly recover within one month (Chapman & Underwood 1996). We did not assess whether visitors were carefully replacing boulders while fossicking; therefore, we suggest that this activity is monitored in the future, as it does have the potential to impact marine communities at Sorrento intertidal reef.

Most rock pool activities were passive and mainly involved adults standing at the edge of rockpools, children swimming and snorkelling at the high and low access sites, or children walking on the rocky outcrop which is used as a platform for diving into the main rockpool at the high access site. Most rockpool activities at the high access site occurred in the main rockpool located in the mid shore. The only exploitative activities associated with rockpools were fishing and collecting. Fishing is a permitted activity at Sorrento, while collecting intertidal shellfish is prohibited (Parks Victoria 1998). Few visitors were observed fishing at Sorrento, with visitors mainly engaging in fishing activities at the low access site. This indicates that fishers at Sorrento prefer to fish from less crowded areas of intertidal reef, at least during the busy summer months. The main impact of fishing on rocky intertidal communities is from collection of biota for bait and trampling (Fairweather 1991; Underwood 1993; Smith & Murray 2005). No fishers were observed collecting biota for bait, suggesting that the main impact that fishers cause at Sorrento intertidal reef is trampling. Due to the small portion of visitors engaged in this activity, we suggest that fishing does not pose a large threat to Sorrento intertidal reef. Sorrento is not considered a popular fishing location (Cooper 2001); therefore, neighbouring rocky intertidal reefs, which are more popular fishing locations, may be more at threat from this activity.

A small proportion of visitors was observed collecting invertebrates at the high access site, most of whom were children collecting invertebrates in buckets. This is unlike other intertidal reefs near urban centres in Victoria and New South Wales where larger proportions of people have been observed collecting, primarily for bait and food (Underwood & Kennelly 1990; Fairweather 1991; Kingsford et al. 1991; Keough et al. 1993; Underwood 1993; Chapman & Underwood 1997; Keough & Quinn 1998). Despite the small number of people observed collecting in our survey, a major shellfish collecting event was observed within a small area of reef to the north-west of high access site at Sorrento and involved approximately ten people during March 2006. Collecting shellfish causes extra patchiness in the distribution of the target species and results in substantial direct and indirect effects on the marine community (Underwood & Kennelly 1990). Collecting events therefore have the potential to impact Sorrento's intertidal marine community.

Management implications of recreational use

The key findings from this study which should be integrated into management of Sorrento intertidal reef include: daily number of cars entering the car park is only a crude estimate of the number of visitors to the high access site; the highest visitor numbers throughout the school holidays and on the weekends in the school term are for the intertidal reef close to the main access points of Sorrento ocean beach; visits on the weekends to the intertidal reef close to the main access points of Sorrento ocean beach are substantially lower during the school term compared to the school holidays; the majority of recreational activities (walking randomly, walking along paths, and activities associated with the main rock pool) are considered passive, with the most popular activities occurring in the mid shore at the high access site; and, the activity which appears to pose the greatest threat to Sorrento intertidal reef is trampling over beds of the brown alga, *Hormosira banksii,* followed by collecting and fossicking.

This study supports the findings of other recreational use studies that have found that most visitors to Victoria's rocky intertidal reefs engage in passive activities, and as a result trampling is the greatest threat to the marine communities (King 1992; Keough et al. 1993; Arundel & Fairweather 2002; Porter & Wescott 2004). A management strategy commonly suggested to reduce the threat of trampling is to restrict public access to some reefs; either by changing public access points, fencing off areas, building boardwalks, or restricting visitors to pre-trampled paths (King 1992; Fletcher & Frid 1996; Keough & Quinn 1998; Carey et al. 2007). By directing the public's attention to explore the high access site at Sorrento, Parks Victoria does restrict access to the local intertidal coastline by treating the high access site as a sacrificial section of reef.

Given the passive nature of the majority of recreational activities occurring on Victorian intertidal reefs, we believe that many visitors are unaware of their contribution to environmental impacts. Public education is a common management strategy to increase visitor's awareness about environmental impacts and provide details of alternative low-impact behaviours which they can adopt (Carlson & Godfrey 1989; Alcock & Zann 1996; Orams 1996; Ferns 2003; Priskin 2003; Scales 2006). Public education can involve interest groups in restoration, remediation, and marine data collection projects, as well as the wider community who are exposed to educational messages through television, newspapers and on-site interpretive signs (Alcock 1991; Alcock & Zann 1996; Howe 2001; Blayney & Wescott 2004; Porter & Wescott 2004; Leigh 2005; Lundquist & Granek 2005; Scales 2006). Despite the popularity of these educational strategies, there has been considerable criticism about their

overall effectiveness in reaching the majority of resource visitors and successfully reducing the occurrence of biologically threatening recreational activities (Alcock & Zann 1996; McKenzie-Mohr & Smith 1999; Alessa et al. 2003; Blayney & Wescott 2004; Porter & Wescott 2004; Wescott 2006). Robinson (2006) has suggested that rather than giving the public advice from experts (e.g. managers, planners and scientists), allowing members of the general public to discuss problems, share lessons and learn from each other may be more successful in promoting behaviour change. This can be facilitated by managers through on site workshops and field trips during peak visitation times. By collaborating with recreational visitors, managers can also gain valuable knowledge of the factors contributing to the passive environmental degradation behaviours seen on rocky intertidal shores and how to enhance voluntary behaviour change (McKenzie-Mohr & Smith 1999; Pickens 2002).

Recreational use surveys can play a beneficial role in the management of intertidal reefs, as interest groups can conduct these surveys without the need for specialist techniques or knowledge (Chapman 1997). By involving interest groups in recreational use surveys, individuals gain many educational benefits and strengthen their relationship with management agencies. Concurrently, management agencies would develop a greater understanding of how recreational use changes seasonally and annually, which could feedback into the development of improved management strategies.

By revealing the peak visitation periods, recreational use surveys can be used as a trigger for management agencies to ensure that impacts are minimised (Boden & Ovington 1973; King 1992). Along with highlighting peak visitation periods, recreational use surveys also highlight the most popular and potentially threatening activities which can be used to feed directly into management strategies. Before management strategies are developed to modify resource use, we stress the importance of determining the site specific ecological consequences of the recreational activities, as the assumption that control is needed may be incorrect (Underwood & Kennelly 1990). By integrating results from recreational use surveys and the site specific ecological impacts of recreational activities, management agencies will be able to devise more effective strategies that will ensure the preservation of both natural and recreational values of natural resources into the future.

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