Smallwood, C.B., Beckley, L.E. and Moore, S.A. (2012) An analysis of visitor movement patterns using travel networks in a large marine park, north-western Australia. Tourism Management, 33 (3). pp. 517-528.

An analysis of visitor movement patterns using travel networks in a large marine park, north-western Australia

Claire B. Smallwood, Lynnath E. Beckley, Susan A. Moore

School of Environmental Science, Murdoch University

Abstract

Good management of tourist destinations can be enhanced by understanding the movement patterns of visitors. Different itinerary types and the concept of distance decay have been explored but there has been little application to within-destination movements or, more broadly, to protected areas. Coastal marine parks offer a challenging location for such research given the connectivity between the water and adjacent land components. The aim of the study was to describe, and quantify, within-destination movement patterns of visitors travelling for recreation throughout Ningaloo Marine Park, in north-western Australia, using various modes of travel. Data were collected using 1208 site-based interviews over a 12-month period. Results revealed visitors were highly dependent on the road network and, once at their accommodation, more than a third did not travel any further to participate in recreation. Conversely, some sites had such a strong attraction that respondents, especially first time and international visitors, travelled long distances for recreation at these sites. These findings contribute to a small, but growing, body of research on within-destination patterns. Such information is essential for protected area planning and to help managers efficiently allocate their often-limited resources.

Keywords: Decay curve; Marine park; Ningaloo Reef; Protected area planning; Visitor surveys

Introduction

Understanding the movement patterns of visitors is important for a number of tourism management activities, such as attraction planning, development of accommodation nodes and transport links (Cole and Daniel, 2003 and McKercher and Lau, 2008). Such understanding may assist with minimising visitor impacts via the redirection, concentration or dispersion of visitors, which is especially pertinent in protected areas as they may attract high numbers of people (McVetty, 2002). Overlaying data on movement patterns with other spatial datasets (e.g. zoning boundaries or habitats) may also enhance the quality of management outputs (Kopperoinen, Shemeikka, & Lindblom, 2004), while quantifying the movement patterns of visitors, in terms of distance travelled, would be useful for supporting management decisions (Zhang, Wall, Du, Gan, & Nie, 1999). Movement patterns can be classified as between- and within-destination, whereby a destination is defined as an area discernable by discrete physical and management boundaries as well as proximity to resources (i.e. attraction or recreation sites) located within one day’s return travel time (WTO, 2007).

The movement of visitors between destinations, and their spatial relationships, can be complex (Xia, Zeephongsekul, & Packer, 2011). Trip itineraries have been studied to help make sense of this complexity, identifying numerous types (Holt and Kearsley, 1998, Lew and McKercher, 2002, Lue et al., 1993, Matley, 1976, Mings and McHugh, 1992 and

Oppermann, 1995). Such complexity stems not only from the wide diversity of routes and attractions from which visitors can choose (Lew & McKercher, 2002), but is also influenced by visitor and visit characteristics (Flognfeldt, 1992 and Xia et al., 2010) and the spatial distribution of resources such as accommodation or infrastructure (Leung & Marion, 1998). Even so, McKercher and Lew (2004) have argued that the various itinerary types can be collapsed into four general themes representing; (1) a single destination trip (which may or may not involve side trips), (2) a transit leg (to a destination area) and accompanying circle tour to participate in activities and stopping overnight at different places, (3) a circle tour with multiple side trips, overnight stays and recreation day trips or, (4) a hub-and-spoke (radial pattern), for which visitors base themselves in a destination area and make side trips to other destinations.

Trips undertaken by visitors once within a destination area are much less studied, but they are also thought to reflect the movement patterns observed for between-destination travel (McKercher & Lau, 2008). Recent empirical studies have begun to identify generalised within-destination movements (Lew and McKercher, 2006 and McKercher and Lau, 2008), however, in broader terms, the distribution of visitors is known to be influenced by infrastructure and access points (Coombes et al., 2009 and Holt and Kearsley, 1998). Distance from population centres also influences visitors, with numbers declining with increasing distance from a point of origin (Murphy & Keller, 1990) which supports the concept of distance decay. This concept has also been primarily considered with respect to between-destination studies, even though it is acknowledged as playing an important role at all spatial scales (Eldridge & Jones, 1991).

The idealised distance decay curve peaks close to the point of origin (i.e. residence or place of accommodation) before declining exponentially due to the increasing perceived costs of time and distance travelled to reach a more distant site (Lew, Hall, & Williams, 2004). However, in tourism and recreation research, actual decay curves have been found with a plateau, resulting from a limited number of tourism opportunities along a linear route, or a secondary peak, caused by distant destinations strongly attracting visitors (Hanink and White, 1999 and McKercher, 1998). Another factor which may also affect distance travelled is that of intervening opportunities, whereby demand for distant sites may decline if an equivalent experience can be obtained at a closer site (McKercher & Lew, 2003).

Ascertaining within-destination movement patterns can be challenging because of the size of the study area, large numbers of people, unconstrained choices and the need for determining movements without affecting normal behaviour (O'Conner, Zerger, & Itami, 2005). Travel along linear networks can be ascertained using map-based techniques, whereby an interviewee traces their travel routes along tracks, roads or waterways (Arnberger & Hinterberger, 2003). It is also possible to collect information on travel routes without maps by using face-to-face interviews to gather data on destinations visited and exit and entry points (Murphy and Keller, 1990 and Tideswell and Faulkner, 1999). More recently, GPS tracking devices have been used to document tourist movement patterns within small confined areas (O'Conner et al., 2005 and Xia et al., 2008) while mobile phones are being used to cover larger areas (Roose, 2010).

In contrast to travel along a linear network, the movement of vessels throughout the marine environment may be extremely diffuse, although features such as navigation aids, shoreline morphology and bathymetry may restrict their distribution (Sidman, Fik, & Sargent, 2004). These spatial features can be combined with information from respondents (e.g. departure locations, destinations or travel routes) to develop a representative boating network (Sidman & Fik, 2005). Alternatively, map-based and electronic GPS tracking have been used successfully to collect data on the distribution of boating activities (Deng et al., 2005 and Pelot and Wu, 2007).

The main aim of the paper was to extend the knowledge base regarding within-destination movement patterns in the challenging context of a large marine park which, due its coastal location, allows visitors to participate in both shore- and boat-based activities. Specific objectives were to; (1) describe within-destination movement patterns, (2) characterise distance decay curves and (3) quantify distance travelled for recreation using various modes of travel. Such a holistic approach to investigating several modes of travel is novel as previous research has focused on a single type, i.e. travel by car (Connell & Page, 2008) or bus (Becken, 2005). The effect of visit and visitor characteristics was also explored. Visitor motivations and the influences on their travel choices, although important, were not the focus of this study.

Methods

Study area

The world heritage nominated Ningaloo Marine Park extends for 300 km along the remote coast of north-western Australia (Fig. 1), encompassing one of the longest fringing coral reef systems in the world (Wilkinson, 2008), and was the focal point for this research. The Marine

Park attracts 200,000 visitors per year and is a clearly defined ‘destination’ due to its isolation from other service centres, which makes it difficult to access on a day trip, whilst its boundary provides a clear distinction from neighbouring areas. The close proximity of the fringing reef crest to the coast, and the presence of a shallow lagoon between the two, allows easy viewing of many fish and coral species by snorkelling from the shore, unlike many other iconic coral reefs, such as the Great Barrier Reef and Florida Keys, which are located further offshore. Visitors are also attracted to this destination by opportunities to interact with whale sharks and manta rays, one of the few places globally where this is possible. Other species such as dugongs, turtles, humpback whales and dolphins are also found within the waters of the Marine Park (Sleeman et al., 2007).

Visitors to Ningaloo Marine Park stay in the nearby towns of Exmouth or Coral Bay (with permanent populations of 2000 and 150 people, respectively) or at camping sites along the adjacent coast. Visitor use is highly seasonal, with peak visitor months during the mild winter months from April to October (Smallwood, Beckley, Moore, & Kobryn, 2011), while the remaining months have few visitors due to the high temperatures and occasional cyclones.

Sampling strategy and questionnaire design

The coastline of Ningaloo Marine Park was surveyed 16 days/month from January to December 2007 to collect spatio-temporal information on patterns of recreational use. A total of 1208 people were intercepted for face-to-face interviews either during, or at the completion of, their recreational activity using a similar method to that developed by Pollock, Jones, and Brown (1994) for recreational fishers. Phone or mail surveys were not suited to this study due to the numerous remote coastal camping locations making it difficult to contact respondents using these methods. Interviews were completed across daylight hours (7.30 am–6 pm) but were constrained to 5–10 per survey due to the long travel times resulting from large distances and poor road conditions (i.e. sandy tracks).

Respondents were selected using quota and purposive sampling to ensure that locations with highest use were sampled more frequently than those with low use, while also obtaining data on a wide spectrum of recreational activity types. Such selection techniques are well documented in recreation and tourism research (Nyaupane et al., 2004 and Sirakaya et al., 2003). Within a group of visitors, a respondent was selected based on who had the next birthday (Battaglia et al., 2008 and Coombes et al., 2009). A high response rate of 99% was obtained which, along with a reduction of biases caused by self-reporting (Beaman et al., 2004 and Tarrant and Manfredo, 1993), is a known benefit of face-to-face interviews (Schirmer & Casey, 2005).

The questionnaire consisted largely of closed-ended questions to facilitate quantitative analyses. The location of each interview was geo-referenced using a handheld Garmin GPS at the commencement of the interview and was followed by a number of questions on visitor characteristics (i.e. age, origin, group size and type) based on standard categories (Horneman, Beeton, & Hockings, 2002) which were central to achieving the research objectives. The main recreational activity that brought the respondent to the beach was recorded, as were place of accommodation (and their reason for choosing it), length of stay and whether the respondent had a boat or off-road vehicle on their current trip. All respondents were asked to identify the location where they had accessed the beach to reach their current recreation (interview) site. The location of their furthest travelled location for shore recreation from a place of accommodation was also recorded. If they had a motorised boat, its characteristics (length, engine horsepower and fuel carrying capacity) were obtained, along with any locations at which the respondent had launched their vessel. Kayaks were also recorded by the interviewer if the respondent had one on their trip. They were also asked to indicate the site to which they had travelled the furthest from their most frequented launch location.

Travel network analysis

Network analysis is constrained to linear pathways which can be described by a series of connected links that are terminated or joined by nodes (Xie & Levinson, 2007). In this study, travel by vehicle from nodes of accommodation to beach access points and boat launching locations was determined using the road network. Road length (km) was the primary attribute, allowing the shortest route in terms of distance to be calculated between two locations using ArcGIS 9.3 Network Analyst. Barriers were used to indicate roads that could not be travelled on, due to closures or limited public access, ensuring an accurate representation of travel routes.

Visitors enter or exit coastal regions adjacent to the Marine Park using nine main access roads (Fig. 1). From these, a web of subsidiary roads and tracks, comprising sand or gravel surfaces, are used to access coastal camping areas and recreation sites. Tracks were mapped during fieldwork using a data logger and imported into ArcGIS 9.3 where attributes such as road length (km) where calculated. Each road and track that was likely to be used by visitors to Ningaloo was also classified according to their function, level of traffic and surface type (Table 1).

Accommodation was available at 87 geo-referenced locations along the coast adjacent to the Marine Park, and in nearby service centres of Exmouth and Coral Bay. These two service centres had several accommodation options available to visitors (e.g. caravan parks, hotels, backpackers) and were aggregated so that all respondents who stayed in these locations were considered to be travelling from the same central geographic reference point (i.e. the 15 accommodation options in Exmouth were combined into a single node) (Table 1). The two caravan parks located outside these service centres offered some facilities (toilets, showers) for visitors and were classified separately to coastal camping areas, where visitors were expected to be self-sufficient. The majority of coastal camping areas were demarcated at some level although, because of the undeveloped nature of large tracts of the coast, some camping did occur at other locations and these sites were individually geo-referenced during surveys. Once the aggregation of accommodation was completed, 56 locations (comprising all types) remained, and were incorporated into the travel network analysis.

Beach access points were nodes defined as any location at which an individual could gain access to the beach on foot or by vehicle. Such points were generally located at the end point of a road (i.e. path leading from a carpark). The 336 beach access points recorded during the study were located at 103 different beaches and were dominated by designated carparks and sandy or gravel tracks developed either formally (by management) or informally (by users), based on a classification adapted from Leung and Marion (1998). Two additional beach access types were also designated for the unique characteristics of Ningaloo, entitled ‘formal (marine)’ and ‘non-fixed’ (Table 1). Beach access points were used to determine the distance travelled (km) by road from accommodation by respondents on the day of interview.

Respondents travelling from a beach access point to a shore recreation site on foot did not use the road network. Therefore, the mean high water mark was used to link these features, as it could take into account convoluted sections of the coastline (unlike calculating the straight line distance). All these travel pathways were overlaid to identify which sections of the coast were most likely to be exposed to high pressures from recreational use. This analysis was completed separately for off-peak (November–March) and peak (April–October) periods to identify any temporal changes in recreational pressure.

During the study, 45 locations were recorded at which vessels could be launched (Table 1). These were mostly sandy beaches where there were no constructed facilities but also included four constructed boat ramps (Fig. 1). Although roads were used to travel from accommodation to a boat launching location, travel by boat from this point to a recreation site could not be calculated using network analysis, as movements are not restricted to a linear pathway. Therefore, a raster-based technique was applied which used information collected during interviews where respondents indicated the maximum distance (km) they had travelled from a launch location. This distance was represented as a circular polygon, clipped to exclude features over which vessels could not travel (i.e. exposed reef crest) or constrained to the lagoon (if the respondent had indicated they had not travelled beyond the fringing reef crest). These polygons were overlaid by a 1 km2 grid and converted to a density of boats within each cell, thereby identifying where vessels were most likely to occur, similar to the method applied by Ward-Geiger, Silber, Baumstark, and Pulfer (2005).

The significance of distances travelled by respondents along the various travel pathways was investigated with respect to visitor and visit characteristics using one-way Analysis of Variance (ANOVA). Data were tested for assumptions of normality and homogeneity and, if violated, were transformed or equivalent non-parametric tests (e.g. Kruskal–Wallis) were applied. Correlations between variables (e.g. distance travelled and boat length) were also explored using Spearman's rank-order correlation, a non-parametric test.

Results

Accommodation to beach access points

Respondents utilised 86% of available accommodation locations and 95% of beach access points. Between these nodes, 237 different pathways were travelled in vehicles along the road and track network, highlighting several trends in the distribution of respondents (Fig. 2). Those staying in the northern part of the Marine Park dispersed to more than 40 beaches for shore recreation, using 63 different beach access points. Respondents staying in Cape Range National Park or within the southern extent of the Marine Park dispersed to less than seven beaches. The only exception to this trend was Coral Bay, at the midpoint of Ningaloo, with respondents travelling to 19 beaches using 51 different beach access points.

At the time of interview, 66% of respondents had travelled in a vehicle away from their accommodation location for shore recreation, while the remaining 34% were more sedentary, and had not travelled, even though at the time of interview the mean duration of their stay had been 15 days. Moreover, there were 16 accommodation locations (all coastal camping) from which, at the time of interview, not one respondent had travelled away from to undertake recreation. These coastal camping areas were all situated to the south of Cape Range National Park, excluding Coral Bay.

The median distance travelled by a respondent by vehicle between accommodation and beach access point was 7 km (SD = 25 km) with a maximum distance of 193 km (Fig. 3a). This distribution had a strong positive skew towards respondents travelling less than 20 km with a subsequent exponential decline with increasing distance, although a secondary peak was evident at about 70 km. As expected from the visual representation of these travel pathways (Fig. 2), those staying in Exmouth and in the two caravan parks to the north of the National Park travelled further, with a mean distance greater than 20 km, when compared to less than 5 km travelled by respondents staying elsewhere along the coast.

Distance travelled by vehicle between accommodation and beach access point was also investigated with respect to visitor and visit characteristics. Significant differences were shown between first time and repeat visitors ($F_{(1,1160)} = 15.83$, $\rho < 0.05$), with first-time visitors travelling further. Visitor origin was also significant ($F_{(4,1157)} = 6.53$, $\rho < 0.05$), with international visitors travelling further than visitors from interstate and regional Western Australia, as was group type ($F_{(4,1156)} = 9.23$, $\rho < 0.05$), in which commercial tour groups travelled the greatest mean distance when compared to other group types (i.e. families, couples). Visitor origin also affected their distribution within the study area, with less residents recorded at popular locations such as Turquoise Bay. Residents were classified as those respondents who resided within the destination area. Length of stay was another variable with significant differences ($F_{(1,1056)} = 6.77$, $\rho < 0.05$), where respondents staying for 1–3 days travelled greater distances than those staying longer.

Respondents were also asked to identify the furthest location to which they had travelled from their accommodation for shore recreation. The median furthest distance was 19 km (SD = 32 km), and when matched against the location at which the interview took place, it revealed that 38% of respondents were at their furthest travelled location when interviewed, and for 16% of respondents this was also their accommodation location.

Beach access point to shore recreation site

Respondents were highly clustered around the 321 beach access points they used to access their chosen site for shore recreation in the Marine Park, travelling on foot a mean distance of less than 100 m along the beach (Fig. 3b). Once again, rapid distance decay was evident. The maximum distance walked by a respondent was 5 km, although this was treated as an outlier and excluded from Fig. 3b.

Mapping the sphere of influence for visitors from beach access points, using the actual distance walked by respondents, highlighted those areas most likely to be exposed to the highest and lowest levels of recreational pressure. There was no significant difference between the distance walked by respondents in off-peak and peak months ($F_{(1,1174)} = 0.843$, $\rho > 0.05$), and the spatial distribution of shore recreation was also similar (Fig. 4a, b). However, peak months had higher densities of recreational use, especially adjacent to the National Park and extending southwards, when compared to off-peak periods. Some sections of coast were also outside the sphere of influence of visitors, as no respondent had travelled on foot in these areas for shore-based recreation.

Distances travelled by foot from beach access points to shore recreation sites were investigated with respect to visitor and visit characteristics, and revealed different trends to those found when respondents travelled by vehicle from their accommodation locations. There were no significant differences between first time and repeat visitors ($F_{(1,1176)} = 2.42$, $\rho > 0.05$), visitor origin ($F_{(1,1173)} = 1.60$, $\rho > 0.05$), group type ($F_{(1,1176)} = 1.60$, $\rho > 0.05$) or length of stay ($F_{(1,1171)} = 0.89$, $\rho > 0.05$).

Accommodation to boat launching locations

Of the 25% of respondents who brought a boat with them on their trip to Ningaloo, 95% had a motorised vessel and 5% had a kayak. Kayaks were excluded from further analysis as more than half had not yet been launched by the respondent at the time of interview. Respondents with motorised vessels utilised 52% of available accommodation locations and 67% of boat launching locations. Between these nodes, 59 different pathways were travelled in vehicles along the road network to launch sites and respondents staying in the northernmost extent of the study area launched their vessels at the widest range of sites (Fig. 5). The majority of respondents (83%) launched their vessels at only one site during their trip to Ningaloo, with four the maximum number (2%). At the time of interview, 58% of respondents had not travelled away from their accommodation to launch their vessels and, as with shore recreation, this trend was strongest to the south of Cape Range National Park.

The median distance travelled between accommodation and boat launching locations along the road network by respondents with motorised vessels was 2 km (SD = 19 km). The distribution had a strong positive skew towards respondents travelling less than 10 km with a subsequent exponential decline (Fig. 3c). There was also a secondary peak evident at about 40 km.

At the time of interview, 65% of respondents had travelled away from their accommodation location to launch their vessel. Respondents staying within, and to the north of the National Park (excluding Exmouth), had travelled more than 25 km whilst those staying further to the south had travelled less than 10 km. Significant differences were also found between the type of boat launching location and vessel length ($F_{(1,262)} = 24.76$, $\rho < 0.05$). Unsurprisingly, vessels launched at constructed ramps had a greater mean length than those launched from beaches.

Boat launching location to boat recreation site

Respondents with motorised vessels were also asked to identify their furthest travelled site for boat-based recreation. Vessels had dispersed up to a median radius of 5 km (SD = 16 km) to a boat recreation site, with a rapid decline in the number of vessels that had travelled greater than 10 km (Fig. 3d). A significant positive relationship (Spearman's rho = 0.51, $\rho < 0.05$) existed between boat length and distance travelled; with larger vessels travelling further. The reef crest also had a significant effect with vessels travelling outside the sheltered lagoon environment having a longer mean length than those remaining within the confines of the lagoon ($F_{(1,204)} = 12.72$, $\rho < 0.05$).

The highest level of use was located in the northern parts of the Marine Park around North West Cape in both off-peak and peak months (Fig. 6). The fringing reef crest did not appear to curtail the distribution of boats in this northern extent, as it is not contiguous along this section of coast. High concentrations of boat use were also found around Lefroy Bay, Coral Bay and 14 Mile, which displayed different patterns to the north, with boating activity clearly concentrated within the sheltered lagoon environment.

Discussion

Within-destination movement patterns

The distribution of respondents participating in recreation within Ningaloo Marine Park was closely linked to the road network along the adjacent coast. Visitors often travelled large distances by vehicle to reach a beach access point or boat launching location, but then travelled only short distances on foot or by boat to reach a specific recreation site. Such findings highlight the importance of the road network as a mechanism for distributing visitors for recreation, as also noted in studies of recreational boaters travelling to launching sites in North America (Reed-Anderson et al., 2000) and beach users in the United Kingdom (Coombes et al., 2009). This knowledge is especially pertinent in a destination such as Ningaloo which encompasses a large area, and has limited road access. Private vehicles offer increased mobility and flexibility to visitors, and understanding the patterns associated with this type of travel are integral for planning and development of infrastructure (Connell & Page, 2008).

At Ningaloo, larger motorised vessels travelled further on the water, and were more likely to move into the exposed ocean beyond the fringing reef crest, than smaller vessels. Sidman et al. (2004) found boat draught had the greatest influence on distribution patterns in Florida while vessel tracking in Canada identified significant differences in movement patters between boat types in terms of distance travelled, coverage and speed (Pelot & Wu, 2007). The location of the fringing reef crest clearly constricts the spatial distribution of vessels at Ningaloo (Fig. 6), but interestingly, as smaller vessels can launch at a greater number of locations, they can potentially impact a greater extent of nearshore environs in the Marine Park than larger vessels.

The longitudinal nature of data collection revealed that the spatial extent of visitors participating in shore-based activities was similar in both off-peak and peak months, while vessels were distributed more widely in peak months. Such temporal variations are rarely identified, as studies are often only undertaken within a short time frame (Coombes et al., 2009) or are more focused on defining the actual pattern of movement (McKercher & Lau, 2008). A temporal analysis of boating in Florida revealed a similar pattern to Ningaloo, with increased density of use in peak visitor periods but with some similarities in the sites at which recreational activities were undertaken (Sidman, Fik, Swett, Sargent, & Fann, 2006). Understanding this temporal variation in visitor movement patterns within a destination is useful for assisting with allocation of management resources to specific sites, especially in protected areas where visitation is balanced with conservation.

Within-destination travel at Ningaloo was characterised by two movement patterns: ‘static’ (no movement) and ‘hub-and-spoke’. Campers staying at remote locations along the coast were more likely to minimise travel once they arrived at their accommodation, reflecting the static movement pattern identified by Lew and McKercher (2006), albeit in the highly urbanised environment of Hong Kong. Security issues are rare in these remote locations and are unlikely to restrict the movement of visitors. This static pattern was especially dominant for those staying along the southern extent of the Marine Park (clearly shown in Fig. 2 and Fig. 5). Dramatic differences in mean length of stay for static visitors in an urbanised environment (4 days) (Lew & McKercher, 2006) when compared the more natural Ningaloo coast (15 days) highlight the need for such studies in protected areas to provide relevant information for managers. One possible explanation for the static nature of visitors to remote coastal camping locations is their attempt to maximise time spent at a location against the significant investment in travel time, which has previously been explored with respect to wilderness areas in North America (Lucas, 1990). This behaviour also has strong similarities with that of visitors to all-inclusive resorts (Lew & McKercher, 2006).

Respondents staying in service centres (with multiple accommodation options) travelled further to reach a beach or launch location to undertake their recreational experience, which is indicative of a hub-and-spoke type pattern (McKercher & Lew, 2004), when compared to those staying at less developed camping sites along the remainder of the coast. The Ningaloo hub-and-spoke pattern was further characterised by a secondary peak in the distance decay curve when examining travel by vehicle from accommodation to either a beach or boat launching location. Such a pattern indicates both the strong attraction of distant recreation sites and uneven spatial configuration of resources (Hanink and White, 1999 and McKercher and Lew, 2003).

A secondary peak in the distance decay curve was not evident in the distance travelled from a beach access to shore recreation site (Fig. 3b) or from a boat launch location to boat recreation site (Fig. 3d). Such a finding indicates a clustering of recreational activity around these departure points, thereby supporting results from the United Kingdom and South Africa where distance from nearest access point was identified as a strong predictor of shore-based beach use (Coombes et al., 2009 and de Ruyck et al., 1997).

The two different itinerary types seem likely to be constructed by visitors with very different characteristics. There were clear differences in the distance travelled by vehicle from accommodation to a beach access between first time and repeat visitors as well as those of different origin, length of stay and group type. First-time (and often) international visitors, as well as those on commercial tours, travelled further by vehicle from their accommodation to a beach access point than repeat visitors. Differences in behaviour due to previous experience have been identified in several previous studies, showing that repeat visitors are more efficient in their travel around a destination (Xia et al., 2008) while first-time visitors are more tourism/travel oriented (Li, Cheng, Kim, & Petrick, 2007). Length of stay is another key determinant of the spatial distribution of visitors (Gokovali et al., 2007 and Oppermann, 1994) and surprisingly, at Ningaloo, respondents staying for short time periods (1–3 days) were more likely to travel greater distances.

Management benefits

Analysis of within-destination movement patterns of visitors in an internationally important protected area, such as Ningaloo, has several benefits for management, especially when providing data across spatial and temporal scales. The resultant information can be used to manage visitor activities, including modifying visitor distribution to minimise impacts, reduce conflicts, and maintain natural resources (McVetty, 2002 and Swett et al., 2004). Several other benefits include the application of such data towards the assessment of infrastructure needs, determination of economic pressures (Swett et al., 2004), risk assessments (Pelot & Wu, 2007) and evaluating the effectiveness of zoning plans as well as accessibility modelling (Bruce & Eliot, 2006).

Although some between-destination research has focused on national parks, quantifying the distance travelled to reach one such destination in China (Zhang et al., 1999), only a small body of within-destination research exists that has been applied to protected areas (Connell and Page, 2008 and O'Conner et al., 2005). Marine parks are another facet of within-destination travel yet to be explored, especially with respect to boat-based recreation which is influenced by different factors when compared to land-based travel. The connectivity between water and adjacent land components also provides an interesting avenue for future investigation, as the location of land-based infrastructure (i.e. boat ramps) is likely to have a strong influence on the distribution of boat-based activities.

Regular collection of information on movement patterns, including quantification of distance travelled, can provide a measure of changing pressure from recreational activities that may require management attention. Temporal variations can also be identified if such data are collected across a year (as demonstrated in Fig. 4 and Fig. 6). As a result, managers can determine if people may need to be re-directed away from a high-use shore recreation site which is at risk of environmental degradation during peak visitor months. The effect of such management attention can also be ascertained. Furthermore, this data can also be used to identify departure points for shore- and boat-based recreation trips, from which locations can be selected to erect signs and distribute information to visitors.

Understanding the generic movement patterns of visitors to protected areas, such as the hub-and-spoke and static patterns at Ningaloo, allow managers to select the best management options for their requirements. For those visitors undertaking a hub-and-spoke pattern, managers may have flexibility and the ability to re-direct visitors for their recreational activities, using information provision at accommodation sites. In contrast, once visitors exhibiting a static pattern have arrived at their accommodation (i.e. camping sites) these are also their recreational sites, so there is limited opportunity, short of site closures, to re-direct them elsewhere. Pre-visit information (Newsome, Moore, & Dowling, 2002) is probably the only reasonable, but much more difficult to implement, solution for these visitors.

The bi-modal decay curve for vehicle travel to reach beach or boat launching location indicates both the attraction to well-advertised sites as well as the limited amount of infrastructure. For boats, the concentration is, in large part, due to the presence of constructed boat launching locations, emphasising the key role of infrastructure in influencing visitor use of marine parks. Many terrestrial protected areas also have similar limited facilities and infrastructure, resulting in extra road traffic, and continued visitor pressure, on popular (and accessible) recreation sites.

Methodological implications

In contrast to most other research, this study relied on face-to-face interviews for data collection, resulting in a high response rate and avoiding the issues, such as response and rounding bias (Pollock et al., 1994), which are associated with some other techniques. Another benefit of a site-based technique is that some information could be verified by the researchers (i.e. recreation location), thereby improving its quality. Other studies have asked respondents to draw their travel routes on maps using mail surveys (Sidman et al., 2004) or provided them with electronic devices to track their movement (Xia et al., 2008). Response rates are notoriously low with such techniques and the cost of electronic trackers may be prohibitive. Moreover, the spatial resolution of some map-based approaches may be limited if the size of the study area is large, resulting in the collection of coarse spatial data (Brown, 2005 and McKercher and Lew, 2004). Therefore, the interview approach used in this current study could be broadly applied to protected areas, given its benefits in providing a large, quantitative dataset on within-destination movement patterns which helped to achieve the three research objectives.

Mapping nodes such as caravan parks and constructed boat launch locations is a straightforward exercise as they are permanent, clearly demarcated features. However, some features, such as the informal accesses described in this study are more ephemeral, and may change over time (as they are created by visitors). New infrastructure may also be created by management. Regular collection of information on movement patterns of visitors within a protected area will ensure that the effects of creating these various features will be documented, which is important for managers who need to understand and influence the distribution of visitors within a protected area.

Determining the travel routes for boats proved particularly challenging given that most other travel analyses assume movement via a linear network. Applying a raster-based approach enabled boat movements through the marine environment to be mapped, and the areas of highest use to be ascertained. This mapping could be further refined by incorporating other datasets, including bathymetry and channel markers, to identify additional areas where vessels cannot navigate. Such techniques have been demonstrated during studies of recreational boating in Florida (Sidman et al., 2004). However, the small size (and consequently shallow draught) of many vessels used at Ningaloo does not really restrict their movement patterns within the lagoon. Similar difficulties in mapping boating patterns could be expected in many nearshore environments without launching facilities for large vessels, and may be addressed via the use of electronic trackers. However, such devices are often limited by their high costs, resulting in small sample sizes for analysis.

Conclusions

This study has contributed to a greater understanding of within-destination movement patterns which, to-date, have received little research attention, especially in protected areas. Respondents staying adjacent to different parts of Ningaloo Marine Park could be predominantly characterised as participating in either a static or hub-and-spoke movement pattern. This is the first documented occurrence of a static movement pattern within the context of a remote destination, with previous studies only identifying this pattern in urbanised or all-inclusive resort environments. A bi-modal decay curve identified within the hub-and-spoke pattern indicated the willingness of visitors to travel to distant locations by vehicle along the road network to reach a favoured recreation site, emphasising yet again the influence of infrastructure on where visitors travel and what they do. As such, managers need to make careful, informed choices about the placement of facilities (including roads and boat ramps) which can dramatically affect the distribution of visitors.

A range of visitor and visit characteristics were used to explore the distances travelled for recreation, highlighting that first time and international visitors travelled further than domestic visitors. Results from quantitative studies such as this can be used to manage visitors’ travel patterns to ensure they obtain optimal experiences, while also protecting valued natural resources. Powerful management tools include pre-visit information, onsite interpretation and careful site design and monitoring. Future research on within-destination movement patterns could benefit from developing a greater understanding the motives behind the behaviours of visitors described in this study.

Acknowledgements

This study was undertaken with the significant financial support of the Australian Government’s CSIRO Wealth from Oceans Ningaloo Collaborative Cluster and Murdoch University. This project was completed under Murdoch University Human Research Ethics Committee Permit Number 2006/272. We would like to acknowledge the assistance of Chris Jones, Dani Rob and Renae Adamson during fieldwork as well as the support of the pastoralists along the Ningaloo coast, the Western Australian Department of Environment and Conservation, Western Australian Department of Fisheries and Commonwealth Department of Defence.

References

Arnberger, A., & Hinterberger, B. (2003). Visitor monitoring methods for managing public use pressures in the Danube Floodplains National Park, Austria. *Journal for Nature Conservation*, *11*, 260-267.

Battaglia, M. P., Link, M. W., Frankel, M. R., Osborn, L., & Mokdad, A. H. (2008). An evaluation of respondent selection methods for household mail surveys. *Public Opinion Quarterly*, *72*, 459-469.

Beaman, J. G., Huan, T. C., & Beaman, J. P. (2004). Tourism surveys: sample size, accuracy, reliability, and acceptable error. *Journal of Travel Research*, *43*, 67-74.

Becken, S. (2005). Towards sustainable transport: an analysis of coach tourism in New Zealand. *Tourism Geographies*, *7*, 23-42.

Brown, G. (2005). Mapping spatial attributes in survey research for natural resource management: methods and applications. *Society and Natural Resources*, *18,* 17-39.

Bruce, E. M., & Eliot, I. (2006). A spatial model for marine park zoning. Coastal Management, *34,* 17-38.

Cole, D. N., & Daniel, T. C. (2003). The science of visitor management in parks and protected areas: from verbal reports to simulation models. *Journal for Nature Conservation*, *11*, 269-277.

Connell, J., & Page, S. J. (2008). Exploring the spatial patterns of car-based tourist travel in Loch Lomond and Trossachs National Park, Scotland. *Tourism Management*, *29*, 561-580.

Coombes, E. G., Jones, A. P., Bateman, I. J., Tratalos, J. A., Gill, J. A., Showler, D. A., et al. (2009). Spatial and temporal modeling of beach use: a case study of East Anglia, UK. *Coastal Management*, *37*, 94-115.

de Ruyck, A., Soares, A. G., & McLachlan, A. (1997). Social carrying capacity as a management tool for sandy beaches. *Journal of Coastal Research*, *13*, 822-830.

Deng, R., Dichmont, D., Milton, D., Haywood, M., Vance, D., Hall, N., et al. (2005). Can vessel monitoring system data also be used to study trawling intensity and population depletion? The example of Australia's northern prawn fishery. *Canadian Journal of Fisheries and Aquatic Sciences*, *62*, 611-622.

Eldridge, D., & Jones, J. P. (1991). Warped space: a geography of distance decay. *Professional Geographer*, *43*, 500-511.

Flognfeldt, T. (1992). Area, site or route: the different movement patterns of travel in Norway. *Tourism Management*, *13*, 145-151.

Gokovali, U., Bahar, O., & Kozak, M. (2007). Determinants of length of stay: a practical use of survival analysis. *Tourism Management*, *28*, 736-746.

Hanink, D. M., & White, K. (1999). Distance effects in the demand for wildland recreational services: the case of national parks in the United States. *Environment and Planning A*, *31*, 477-492.

Holt, A., & Kearsley, G. W. (1998). The modelling of visitor flow patterns. In *10th Colloquium of the Spatial Information Research Centre: Towards the next decade of spatial information research*. New Zealand: University of Otago.

Horneman, L. N., Beeton, R. J. S., & Hockings, M. (2002). *Monitoring visitors to natural areas: A manual with standard methodological guidelines*. Queensland, Australia: Queensland Parks and Wildlife Service, New South Wales National Parks and Wildlife Service, Sport and Recreation Queensland, University of Queensland.

Kopperoinen, L., Shemeikka, P. J., & Lindblom, V. (2004). Environmental GIS in the management of visitor flows. In *2nd International conference on monitoring and management of visitor flows in recreational and protected areas,* Rovaniemi, Finland.

Leung, Y. F., & Marion, J. L. (1998). Evaluating spatial qualities of visitor impacts on recreation resources: an index approach. *Journal of Applied Recreation Research, 23,* 367-389.

Lew, A., Hall, M. C., & Williams, A. M. (Eds.). (2004). *A companion to tourism*. New York, USA: Wiley-Blackwell.

Lew, A., & McKercher, B. (2002). Trip destinations, gateways and itineraries: the example of Hong Kong. *Tourism Management, 23*, 609-621.

Lew, A., & McKercher, B. (2006). Modeling tourism movements: a local destination analysis. *Annals of Tourism Research, 33*, 403-423.

Li, X., Cheng, C. K., Kim, H., & Petrick, J. F. (2007). A systematic comparison of first-time and repeat visitors via a two-phase online survey. *Tourism Management, 29*, 278-293.

Lucas, R. C. (1990). *How wilderness visitors choose entry points and campsites.* Ogden, USA: Department of Agriculture, Forest Service, Intermountain Research Station.

Lue, C. C., Crompton, J. L., & Fresenmaier, D. R. (1993). Conceptualisation of multi-destination pleasure trips. *Annals of Tourism Research, 20*, 289-301.

Matley, I. M. (1976). *The geography of international tourism.* Washington, USA: Association of American Geographers.

McKercher, B. (1998). The effect of distance decay on visitor mix at coastal destinations. *Pacific Tourism Review, 2*, 215-224.

McKercher, B., & Lau, G. (2008). Movement patterns of tourists within a destination. *Tourism Geographies, 10,* 355-374.

McKercher, B., & Lew, A. (2003). Distance decay and the impact of effective tourism exclusion zones on international travel flows. *Journal of Travel Research, 42*, 159-165.

McKercher, B., & Lew, A. (2004). Tourist flows and the spatial distribution of tourists. In A. Lew, M. C. Hall, & A. M. Williams (Eds.), *A companion to tourism* (pp. 36-48). Oxford, London: Blackwell Publishing.

McVetty, D. (2002). Understanding visitor flows in Canada's national parks: the patterns of visitor use study in Banff, Kootenay and Yoho National Parks. *In 1st International conference on monitoring and management of visitor flows in recreational protected areas*, Vienna, Austria.

Mings, R. C., & McHugh, K. C. (1992). The spatial configuration of travel to Yellowstone National Park. *Journal of Travel Research, 30*, 38-46.

Murphy, P. E., & Keller, C. P. (1990). Destination travel patterns: an examination and modeling of tourist patterns on Vancouver Island, British Columbia. *Leisure Sciences, 12,* 49-65.

Newsome, D., Moore, S. A., & Dowling, R. (2002). *Natural area tourism: Ecology impacts and management*. Clevedon, England: Channel View Publications.

Nyaupane, G. P., Morais, D. B., & Graefe, A. R. (2004). Nature tourism constraints: a cross-activity comparison. *Annals of Tourism Research, 31*, 540-555.

O'Conner, A., Zerger, A., & Itami, B. (2005). Geo-temporal tracking and analysis of tourist movement. *Mathematics and Computers in Simulation, 69*, 135-150.

Oppermann, M. (1994). Length of stay and spatial distribution. *Annals of Tourism Research*, *21*, 834-836.

Oppermann, M. (1995). A model of travel itineraries. *Journal of Travel Research, 33,* 57-61.

Pelot, R., & Wu, Y. (2007). Classification of recreational boat types based on trajectory patterns. *Pattern Recognition Letters*, *28,* 1987-1994.

Pollock, K. H., Jones, C. M., & Brown, T. L. (1994). *Angler survey methods and their applications in fisheries management.* Maryland, USA: American Fisheries Society.

Reed-Anderson, T., Bennett, E. M., Jorgensen, B. S., Lauster, G., Lewis, B., Nowacek, D., et al. (2000). Distribution of recreational boating across lakes: do landscape variables affect recreational use? *Freshwater Biology, 43,* 439-448.

Roose, A. (2010). Designing visitor monitoring system in Estonian nature reserves combining passive mobile positioning with other counting methods. In *5th International conference on monitoring and management of visitor flows in recreational and protected areas,* Wageningen, Netherlands.

Schirmer, J., & Casey, A. M. (2005). Social assessment handbook: *A guide to methods and approaches for assessing the social sustainability of fisheries in Australia.* Canberra, Australia: Bureau of Rural Sciences.

Sidman, C. F., & Fik, T. J. (2005). Modeling spatial patterns of recreational boaters: vessel, behavioural, and geographic considerations. *Leisure Sciences, 27,* 175-189.

Sidman, C. F., Fik, T. J., & Sargent, B. (2004). *A recreational boating characterisation for Tampa and Sarasota Bays.* Florida, USA: University of Florida Sea Grant Program.

Sidman, C. F., Fik, T. J., Swett, R. C., Sargent, B., & Fann, S. (2006). *Greater Charlotte Harbour: A comparison of boating patterns by season*. Florida, USA: University of Florida Sea Grant Program.

Sirakaya, E., Uysal, M., & Yoshioka, C. F. (2003). Segmenting the Japanese tour market to Turkey. *Journal of Travel Research*, *41*, 293-304.

Sleeman, J. C., Meekan, M. G., Wilson, S. G., Jenner, C. K. S., Jenner, M. N., Boggs, G. S., et al. (2007). Biophysical correlates of relative abundances of marine megafauna at Ningaloo Reef, Western Australia. *Marine and Freshwater Research, 58,* 608-623.

Smallwood, C. B., Beckley, L. E., Moore, S. A., & Kobryn, H. T. (2011). Assessing patterns of recreational use in large marine parks: a case study from Ningaloo Marine Park, Australia. *Ocean and Coastal Management, 54*, 330-340.

Swett, R. C., Sidman, C. F., Fik, T. J., & Sargent, B. (2004). *Florida's vessel title registration system as a source of boat locations and characteristics: A case study in Lee and Manatee Counties*. Florida, USA: University of Florida Sea Grant Program.

Tarrant, M. A., & Manfredo, M. J. (1993). Digit preference, recall bias and nonresponse bias in self reports of angling participation. *Leisure Sciences, 15,* 231-248.

Tideswell, C., & Faulkner, B. (1999). Multidestination travel patterns of international visitors to Queensland. *Journal of Travel Research, 37,* 364-375.

Ward-Geiger, L. I., Silber, G. K., Baumstark, R. D., & Pulfer, T. L. (2005). Characterization of ship traffic in right whale critical habitat. *Coastal Management, 33,* 263-278.

Wilkinson, C. R. (2008). *Status of coral reefs of the world: 2008*. Townsville, Australia: Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre.

WTO (World Tourism Organisation). (2007). *A practical guide to tourism destination management.* Madrid, Spain: World Tourism Organisation.

Xia, J., Arrowsmith, C., Jackson, M., & Cartwright,W. (2008). The wayfinding process relationships between decision-making and landmark utility. *Tourism Management, 29*, 445-457.

Xia, J., Evans, F. H., Spilsbury, K., Ciesielski, V., Arrowsmith, C., & Wright, G. (2010). Market segments based on the dominant movement patterns of tourists. *Tourism Management, 31*,464-469.

Xia, J., Zeephongsekul, P., & Packer, D. (2011). Spatial and temporalmodelling of tourist movements using Semi-Markov processes. *Tourism Management, 32*, 844-851.

Xie, F., & Levinson, D. (2007). Measuring the structure of road networks. *Geographical Analysis, 39*, 336-356.

Zhang, J.,Wall, G., Du, J. K., Gan, M. Y., & Nie, X. (1999). The travel patterns and travel distance of tourists to national parks in China. *Asia Pacific Journal of Tourism Research, 4*, 27-34.

Fig. 1. Ningaloo Marine Park in north-western Australia.

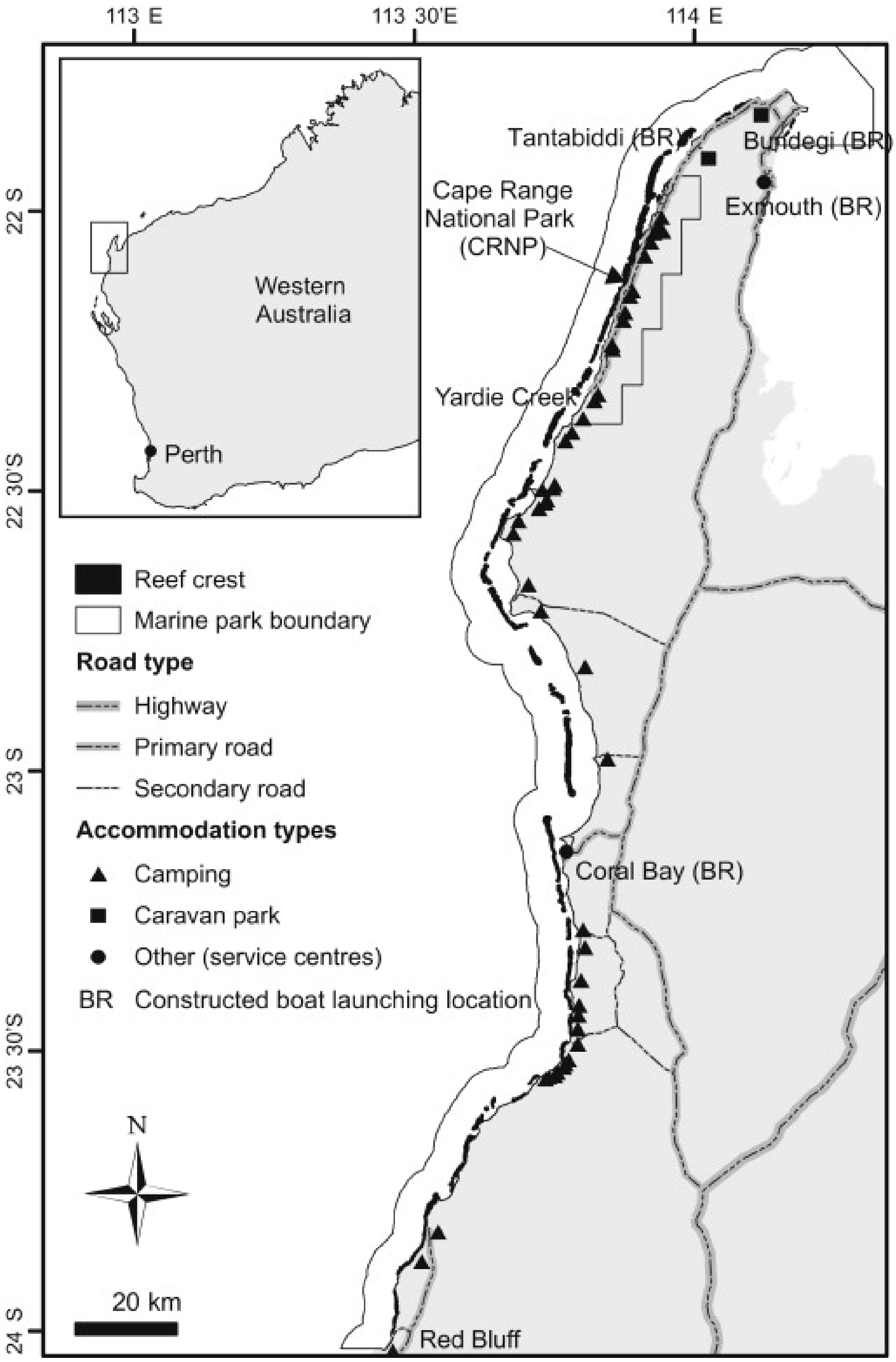

Fig. 2. Pathways travelled by respondents in vehicles between accommodation and beach access points (number of interviews = 1188). Note: horizontal lines represent no travel by vehicle.

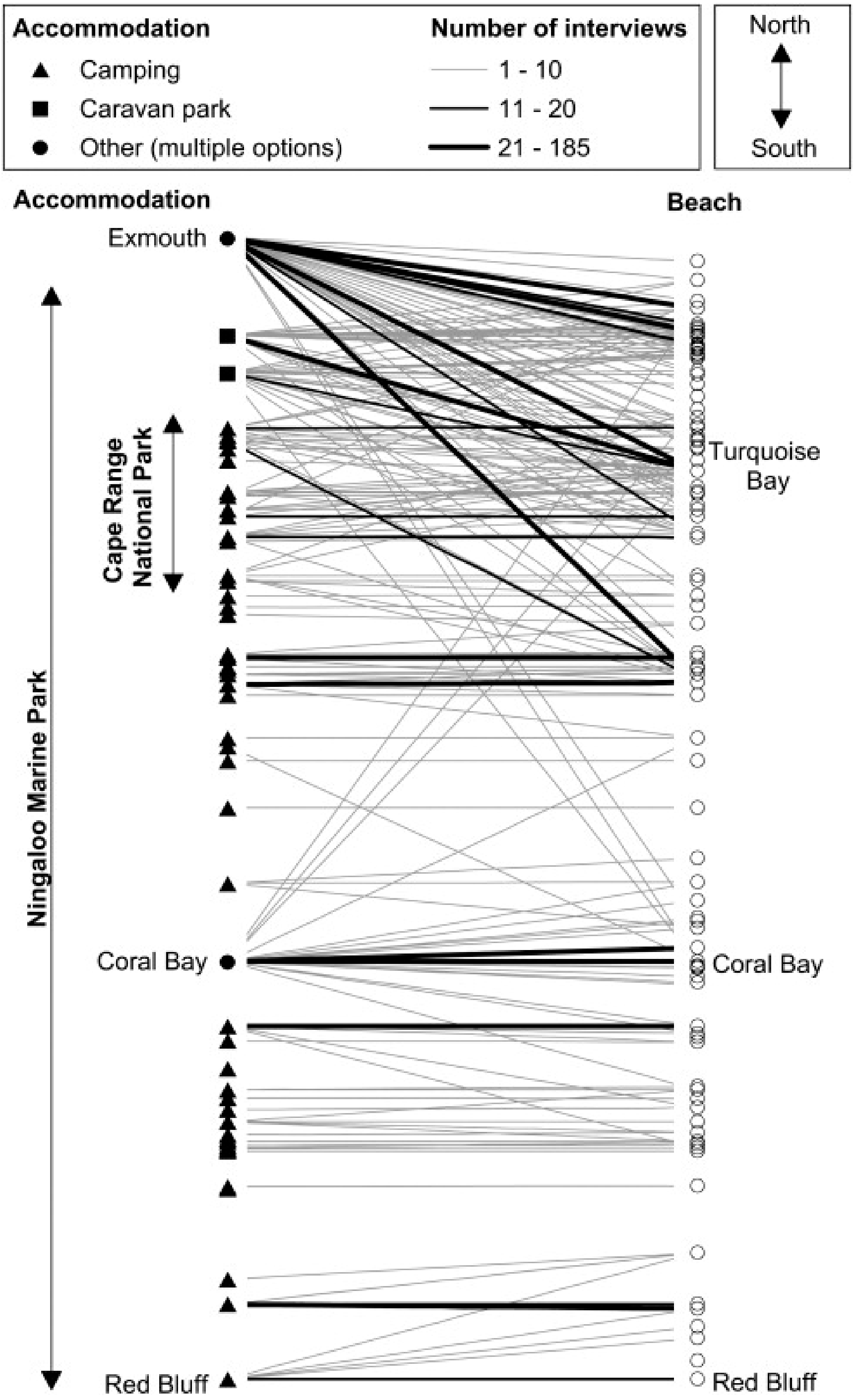

Fig. 3. Histogram of distance travelled along each pathway from (a) accommodation to beach access, (b) accommodation to boat launch location, (c) beach access to shore recreation site, and (d) boat launch location to boat recreation site. Dotted line is an interpolated spline representing the distance decay curve (number of interviews = 1208).

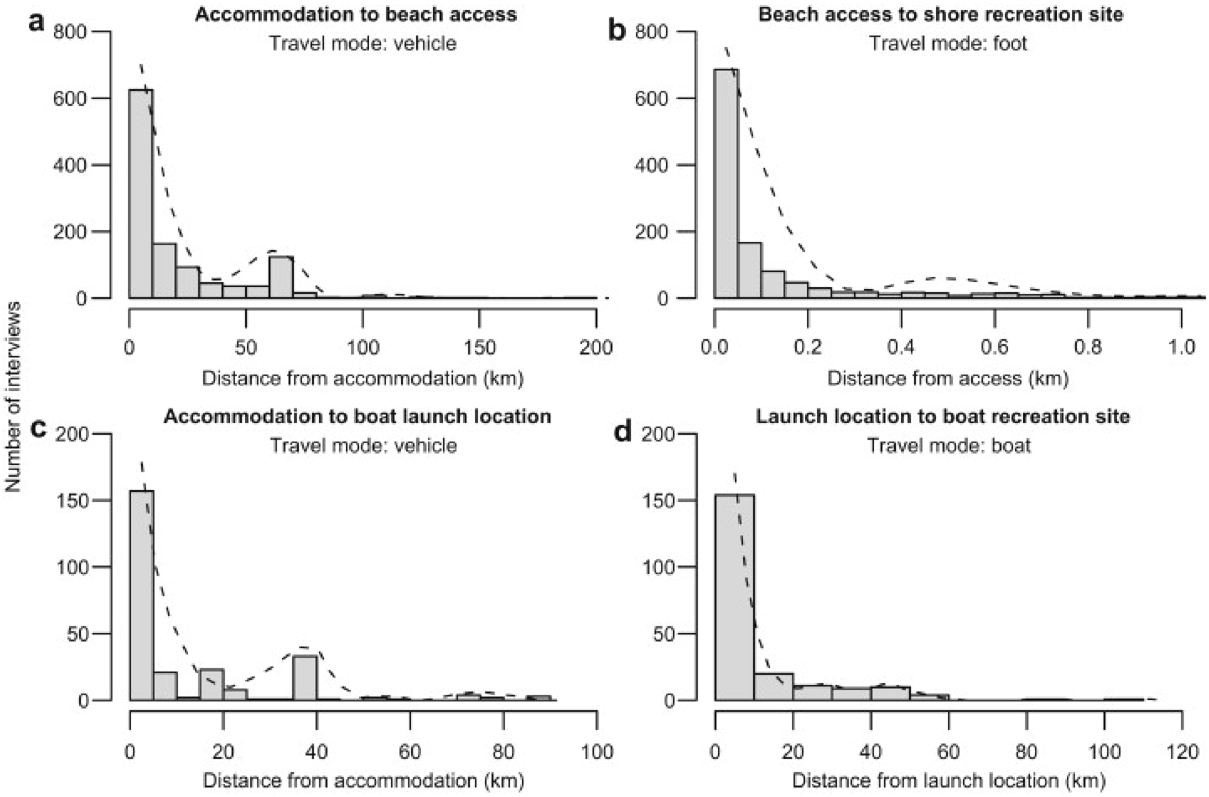

Fig. 4. Coastal areas exposed to the highest density of recreational use by respondents travelling on foot from a beach access to shore recreation site in (a) off-peak and (b) peak months (number of interviews = 1208).

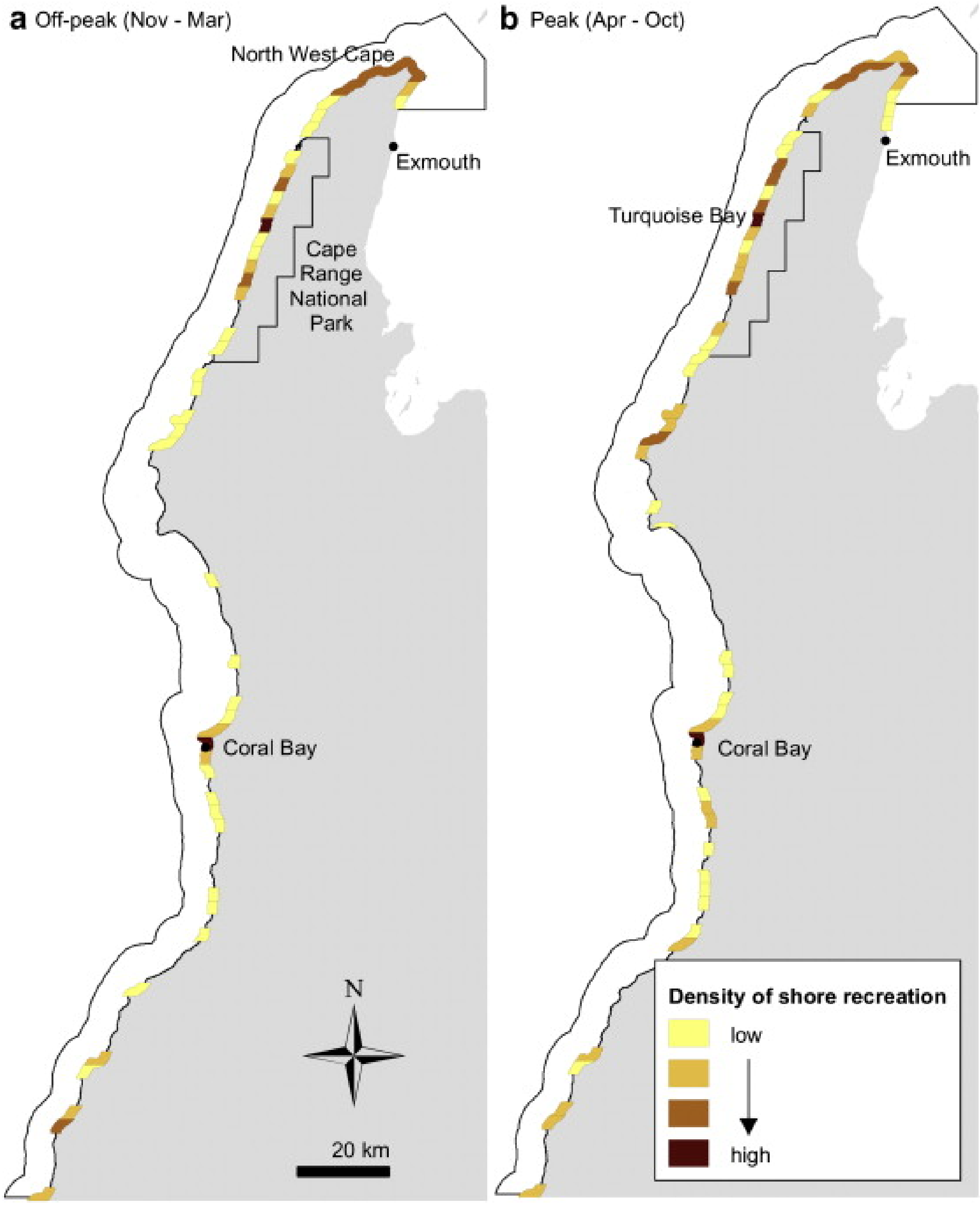

Fig. 5. Pathways travelled by respondents in vehicles between accommodation and boat launching location (number of interviews = 267). Note: horizontal lines represent no travel by vehicle.

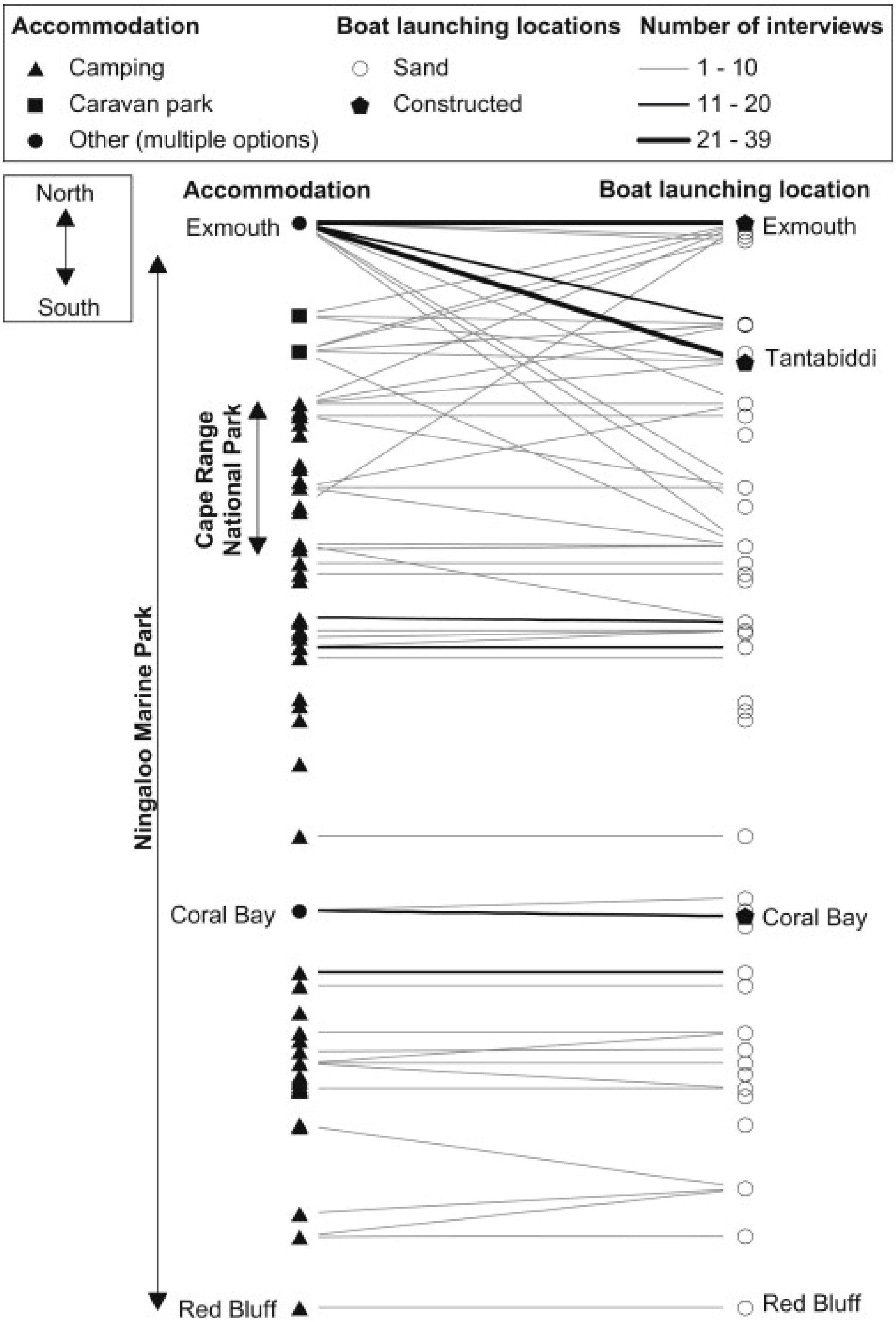

Fig. 6. Areas with highest potential density of use by motorised recreational vessels, based on the radius travelled from a boat launching location to recreation site in (a) off-peak and (b) peak months (number of interviews = 210).

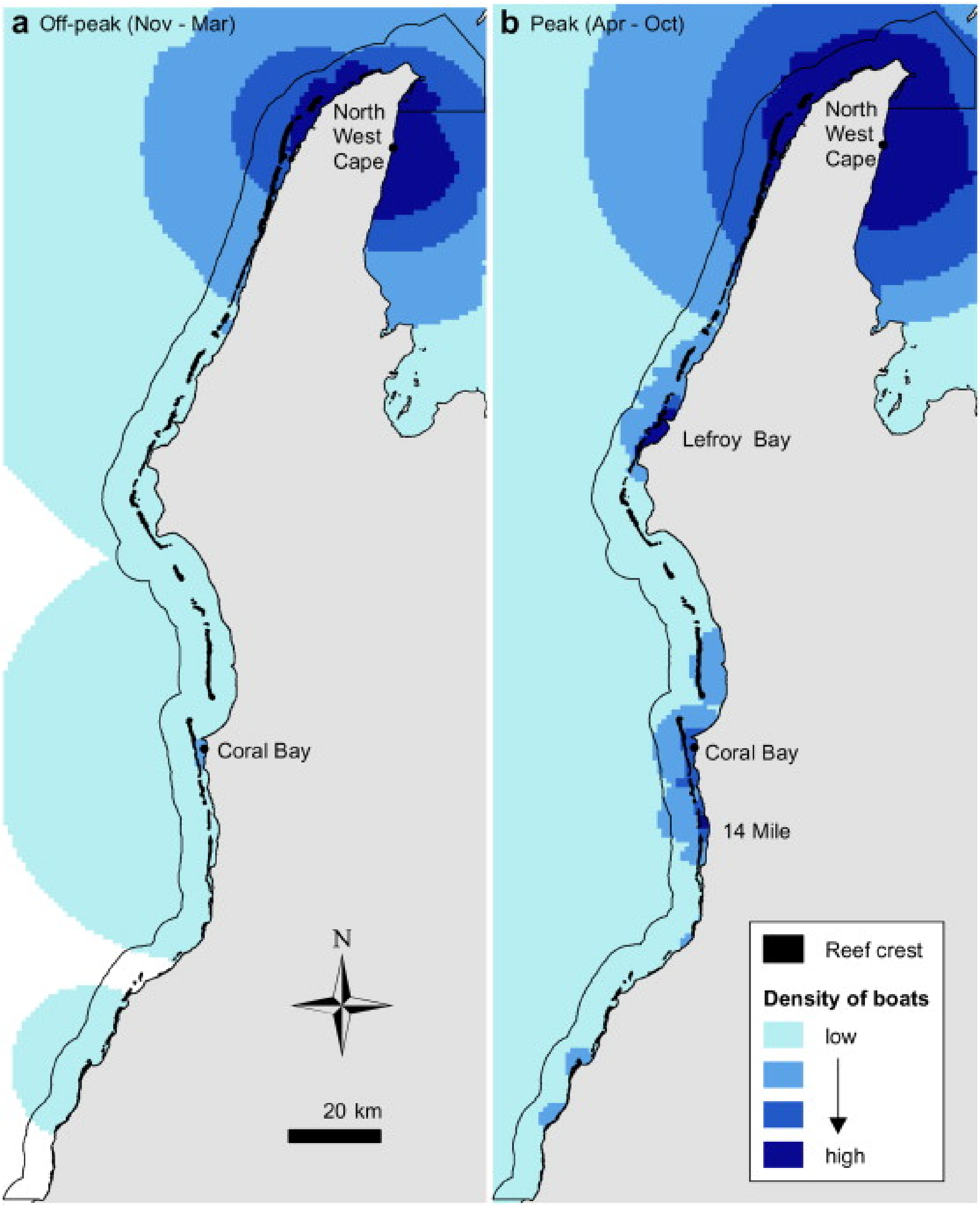

Table 1. Description of the network elements used for travel network analysis.

Network element (type)	**Description**
Road type (link)	
Highway	Major sealed connecting roads between towns.
Main road	Distributes traffic between highways. Split into primary (sealed) and secondary (gravel) roads.
Track	Sand or gravel road of minimal construction connecting other roads or leading to a feature.
Accommodation location (node)	
Coastal camping (N = 52)	Camping areas along the coastal strip where visitors are generally self-sufficient.
Caravan parks (N = 2)	Established area with facilities in which visitors can stay in demarcated sites using tents, caravans or onsite chalets.
Other (N = 2)	Multiple accommodation options (i.e. hotels and private residences).
Beach access point (node)	
Formal (N = 56)	Endpoint of road with carpark created by management using some form of demarcation.
Informal (N = 67)	Endpoint of track with space for vehicle parking but which was created and perpetuated by unmanaged visitor use.
Formal (marine) (N = 4)	Constructed feature whose primary purpose was not for recreation (i.e. jetty, boat ramp), but is used by visitors as such.
Non-fixed (N = 209)	Visitors directly access the beach for recreation from campsite or vehicle. Difficult to identify as visitors may camp directly on the beach.
Boat launching location (node)	
Constructed (N = 4)	Locations with concreted boat ramp and finger jetty.
Beach (N = 41)	Locations where vessels could be launched directly off the beach.