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Challenging tourism theory through integrated models: how multiple model projects strengthen outcomes through a case study of tourism development on the Ningaloo Coast of Western Australia

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Abstract: This paper has the dual purpose of challenging tourism planning theory through modelling, and reflecting on the multi-model collaboration that made this possible and extended the reach of a tourism modelling project. As such it provides a practice-oriented reflection on collaboration between modelling projects grounded in a discussion of model outputs and extension activities.

The Ningaloo Destination Modelling (NDM) project was one of five research projects within the Ningaloo Collaboration Cluster, a program of research that was funded by the CSIRO's Wealth from Oceans Flagship. The NDM project was also funded by the Sustainable Tourism CRC, and collaborated with a number of organisations including two Shires, state agencies, utility providers, tourism businesses and the Gascoyne Development Commission to gather data and refine model features and dynamics. The Ningaloo Collaboration Cluster focussed on the Ningaloo Coast, encompassing the Shires of Carnarvon and Exmouth, in the northwest of Western Australia. Beginning 900 km north of Perth, the Ningaloo Coast is a remote tourism destination with a resident population of approximately 8000. It attracts between 170 000 and 200 000 tourists a year. The growth of tourism and tourism development opportunities relies on the attraction of the region's remoteness and a delicate ecosystem linked to a fringing coral reef that is over 300 kilometres long. Thus inappropriate tourism development and visitor growth could jeopardise the future of tourism and alienate locals who place a high importance on the natural environment.

Tourism is an activity that transforms places and communities. It has a variety of thresholds that have been linked to economic, social and ecological change. The most widely used model of tourism development, Richard Butlers Tourism Area Life Cycle (TALC) model identifies these transformations and thresholds, linking impacts to six stages of development that are determined by the relationship between visitor numbers and time. Using four feedback loops (accommodation capacity, worker availability, social impacts, and visitor response to environmental regulation) together with visitor preferences, the NDM captures the transformative elements of the TALC, and moves away from deterministic assumptions linking impacts to a "stage" of development. Equally important, development strategies that lessen the undesirable impacts of development can be explored, indicating that the TALC stages are not the sole direction that tourism development need follow. This is demonstrated in the paper through a case study of a remote tourism node on Gnaraloo Station, in the middle of the Ningaloo Coast. A thread that runs through this paper is the influence of multiple modelling projects within the Ningaloo Collaboration Cluster. The most important influence from the perspective of this paper was the modelling results, where integration with an ecological model of the region provided a range of ecological indicators that indicate the influence on key environmental attractions.

Keywords: *Sustainable Tourism, multi-model projects, Ningaloo, modelling*

1. INTRODUCTION

Sustainable tourism planning expands the range of fields that a planning exercise needs to address (Hall, 2000), and puts an onus on planners to ensure that the planning process is collaborative in the full sense of the word (Bramwell & Lane, 1999). Planning has shifted over the past twenty years from a 'booster' approach to tourism, where the aim was to increase tourist numbers, to an expectation that it will address social, environmental and cultural impacts as well as economic impacts, and will provide a balanced and nuanced approach (Hall, 2000; Inskeep, 1991). Scale is an important element here, as the capacities, uses and connections of a place need to be considered at different scales (vertically) and across locations (horizontally), and linked to ecological and social processes specific to a location and region (Holling & Gunderson, 2002).

This paper focuses on how tourism, economic, environmental and social elements were integrated in the NDM to create a sustainable tourism planning tool. While it is acknowledged that engagement is the key determinant of model uptake (Schianetz *et al.*, 2007), the process of engagement is addressed in Jones *et al.* (2011a, 2011b) and Schianetz et al. (2009). We focus on the technical elements of the modelling: providing an explanation of the model structure, and exploring the dynamics and outcomes of the model through a case study of a development site on Gnaraloo Station. We then reflect on the benefits of collaboration between modellers in an interdisciplinary modelling project.

Recommendation for Gnaraloo Station: Tourism node

Gnaraloo and environs is suitable for a tourism node due to the scale and configuration of land available, majestic views, and established access and infrastructure. Other benefits include proximity to an airstrip, Gnaraloo Bay, remote coastline (potentially roadless) to the north, Three Mile Camp and extraordinary surf breaks, pocket beaches and rocky coastal features.

Source: (WAPC, 2004: 59)

2. BACKGROUND

The Ningaloo Destination Modelling (NDM) project was one of five research projects within the Ningaloo Collaboration Cluster, a program of research that was funded by the CSIRO's Wealth from Oceans Flagship. The NDM project was also funded by the Sustainable Tourism CRC, and collaborated with a number of organisations including two Shires, state agencies, utility providers, tourism businesses and the Gascoyne Development Commission to gather data and refine model features and dynamics. The Ningaloo Collaboration Cluster focussed on the Ningaloo Coast, encompassing the Shires of Carnarvon and Exmouth, in the northwest of Western Australia.

The Ningaloo Coastal region stretches from Carnarvon in the south to the Muiron Islands in the north. It is known primarily for the Ningaloo Reef, the largest fringing coral reef in Australia stretching over 300 km along the northwest coast between the towns of Carnarvon and Exmouth (Figure 1). The region includes 7 745 residents living mainly in Carnarvon (71%), Exmouth (27%) and Coral Bay (2%). The majority of land in the area is held within pastoral leases. Carnarvon, the southern-most tip of the Ningaloo Coast region, is 905 km from Western Australia's capital city of Perth. The region's economy is based on tourism, fishing, mining, horticulture and livestock, with tourism being the most important economic activity. The Ningaloo Coast is a remote tourism destination with a resident population of approximately 8000. It attracts between 170 000 and 200 000 tourists a year.

The region has exceptional conservation values, including marine and terrestrial flora and fauna, karst formations and subterranean fauna, and remoteness values. Nature-based and wilderness tourism is the main source of income in Exmouth and Coral Bay, and the region is marketed nationally and internationally as a premier tourism destination (Western Australian Tourism Commission, 2003). The two most prominent protected areas for tourism are Cape Range National Park and the Ningaloo Marine Park, Western Australia's premier marine tourism resource.

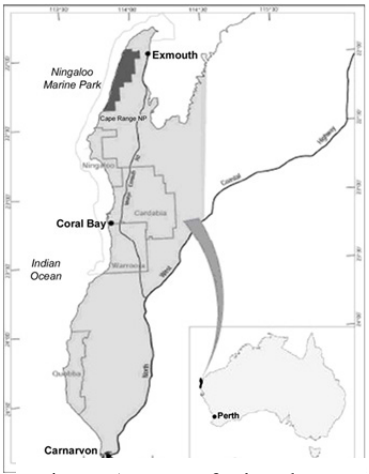

Figure 1: Map of Ningaloo

Gnaraloo is a working pastoral station and wilderness tourism business adjacent to the Ningaloo Marine Park 150 kilometres north of Carnarvon, Western Australian. The current owner, Paul Richardson, has reduced sheep numbers considerably and has concentrated on building tourism on Gnaraloo. Richardson also owns Three Mile Camp, the most popular campground on the coast due to its proximity to popular surf breaks such as Tombstones. In addition to surfing, windsurfing and kite-surfing, the area is also popular for snorkelling, going to the beach, and fishing. Access is along a dirt road of variable quality that is most suited to four wheel drive vehicles. The *Ningaloo Coast Regional Strategy* (Western Australian Planning Commission, 2004) has Gnaraloo station zoned as a tourism node

that can cater for up to 500 overnight visitors.

The tourism nodes outlined in the *Regional Strategy* have the capacity to provide a range of accommodation types and services, depending on master planning and approvals. At present Gnaraloo can accommodate a maximum of approximately 100 visitors, in chalets and bunkhouse accommodation. The *Regional Strategy* assesses the homestead to be "moderately" sensitive with low grasses and remnant native species, and pockets of significant coastal vegetation. The area has been home to grazing for over 90 years. The tourism node is separated from the coast by a mobile sand dune, but is still appealing due to the spectacular coastal views from its elevated position, and access to snorkelling and beach attractions, which are a short drive away.

The potential exists for a five-fold increase in people on the station. Although this size is not the plan of the current owner, the flexibility in the *Regional Strategy* means that such growth is a possibility. Constraints to further development include environmental impacts, infrastructure (water, waste water, electricity, sewerage) and local opposition to development near a popular local beach and surf break. The NDM can help assess different types and sizes of tourism development for Gnaraloo Homestead, demonstrated here through modelling outcomes of two extremes: a caravan park development and a hotel development, both built to maximum capacity.

3. METHODS

The methodology followed here is based on system dynamics modelling, developed from the work of Senge (1990) and Sterman (2000) using Vensim software. System dynamics has been used successfully in Australia, including the Port Douglas (Walker *et al.*, 1999) and Tapestry (Walker *et al.*, 2005) regions.[1] Modelling can facilitate problem definition and formulating and testing of potential solutions. After addressing the concept of destination development, the remainder of this section addresses the dynamics of the numerical model.

The most used model in tourism research is the Tourism Area Life Cycle (TALC) model developed by Richard Butler (2006). Butler suggests that tourism destinations go through a series of development stages. His six stages are:

- Exploration, where an area is 'discovered' by explorers who are attracted by its raw beauty or culture.
- Involvement, where a growing stream of visitors begins to catalyse local initiatives to cater exclusively for visitors.
- Development, a dynamic growth period where large numbers of new visitors come to the region, and outside investment begins to the detriment of local participation and control. The region also begins to lose its attractiveness for explorers.
- Consolidation, where visitor numbers continue to increase but at a declining rate, regulation increases, and efforts increase to extend the tourism season.
- Stagnation, where visitor numbers stabilise as threshold levels are reached or exceeded, resulting in economic, social or environmental problems. Tourism has now become mass market, with lower yields.
- Decline or rejuvenation where the destination either fails to address its economic, environmental and social problems and declines, or there is a dramatic change in the resource base as the destination reinvents itself through finding a new resource (natural or cultural) to exploit.

Heywood (2006: 53) argues that TALC researchers view the destination 'through the wrong end of the telescope', where the 'details melt into amorphous blobs'. He notes that 'when viewed closely, the tourism organisations and the people could be observed making choices continuously' (2006: 53). TALC assumes particular kinds of changes as destinations grow, but does not explicitly and in detail link these changes to the preferences of different kinds of visitors and the characteristics of the region. Limits to growth, such as worker, accommodation or resource (primarily water and electricity) shortages, can slow the cycle, and decisions about different kinds of accommodation and regulation also influence the changing visitor mix, which influences patterns of activities and expenditure that flow on to cause social and environmental impacts. As such, the Ningaloo Destination Model is a response to Heywood's criticism that 'TALC research needs to become better attuned to discovering the interplay of the dominant forces that cause a destination to advance or decline, particularly in respect to capacity management' (2006: 55).

Before turning to the different elements of the NDM, including the integration with Beth Fulton's ecological model of Ningaloo which greatly expanded the NDM's range of indicators and uses, it is worthwhile noting how engagement influences the methodologies of the modelling project involved, particularly at the level of engagement. The NDM was focussed on tourism and land use planning, and was engaging with local groups and land management agencies in Perth. Working with Fulton and her team led to a greater engagement with Fisheries in particular, but also with mining companies, due to the background of her team in the assessment of

[1] Paul Walker was also involved in the NDM project, assisting with the initial workshops and providing advice at various points in model development.

marine industries (including offshore oil and gas). Fulton's engagement strategy for the region was enhanced by the longer term relationships that the NDM team, particularly David Wood and Tod Jones, had built in the region. Furthermore, the two greatest areas of concern in the workshops were effects on tourism and the environment. The NDM teams expertise in tourism and Fulton's expertise in ecological assessment meant that

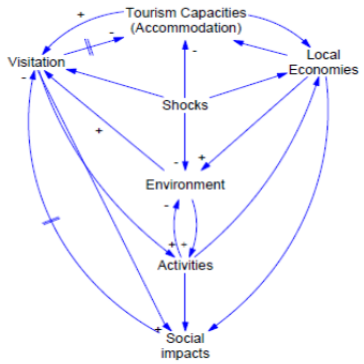

Figure 2: Conceptual Model

the two teams were well positioned to address the range of issues that typically were raised when discussing the research in small and large groups.

The key relationships in the NDM are identified in the conceptual model (Figure 2). The central element in the tourism system is the destination's capacity to accommodate tourists. This is certainly the case for the Ningaloo Coast where all of the accommodation is taken up for school holidays. Before determining the number of people that can fit in the region, we need to identify the total number of visitor nights during a specific tourism season. This is represented by the equation:

$$N_t = \sum_r \left(v_{str} l_{sr} g_t \right) \tag{1}$$

Where N_t is the visitor nights in tourist season t, r is the subregion, v is the number of visitors, s is the visitor segment, l is the length of stay and g is the visitor growth rate. On Ningaloo, there are six tourist seasons that were defined through interviews with tourism industry members and confirmed through visitor surveys. The accommodation capacity limit on growth is not through total visitor nights, but related to accommodation preferences and the number of visitors in a subregion on a specific night. Visitor nights spent in different accommodation types are captured by:

$$N_{tra} = N_t a_{str} \tag{2}$$

Where a_{str} is the accommodation of visitor segment s in tourism season t in subregion r.[2] To calculate how many people are in the subregion on a given night, we calculated the average number of visitor nights per night for each of the subregions by dividing (2) by the number of nights in tourist season t (represented by n_t):

$$\overline{N}_{tra} = \frac{N_t a_{str}}{n_t} \tag{3}$$

The limiting feedback loop for accommodation can therefore be defined as:

$$g = \begin{cases} 0, & \overline{N}_{tra} \le A_r \\ XYZ, & \text{otherwise} \end{cases} \tag{4}$$

Where A is the accommodation capacity in subregion r.

Economic impacts are linked to different visitor types. As the visitor mix changes, the average expenditure per visitor also shifts. This information is taken from 1574 visitor surveys collected for the project. Expenditure can be calculated by:

$$E_{rt} = N_{srt} e_s \tag{5}$$

where E_{rt} is the total expenditure at time t in subregion r, N_{srt} is the visitor nights of visitor segments s at time t in subregion r, and e is the average nightly expenditure of visitor segments s.

A second limiting factor is worker availability, which is constrained by a lack of residential accommodation. Residential accommodation competes with holiday accommodation, particularly in Exmouth and Coral Bay, where a number of houses are rented to visitors. The key variable here is demand for new workers, D_r in subregion r, which is calculated through a regionally specific ratio between expenditure and workers required, j developed in other research (Hughes *et al.*, 2008),

[2] Details on the different types of data that can be generated by the NDM can be found in Chapter 6 of the Socioeconomics of Tourism Report, along with a table summarising the symbols used in the equations in this paper, which are not included here due to length restrictions. The report is available for free download from www.ningaloo.org.au. Alternatively, a longer version of the paper is available from the first author.

$$D_{tr} = \frac{N_{srt} e_s}{j} \tag{5}$$

where e is average visitor expenditure per night for visitor segment s. Workers accommodation restricts growth when demand for workers outstrips housing availability. This can be summarised as:

$$g = \begin{cases} 0\,,\ D_{tr} z_r + y_r \geq H_r \\ XYZ,\ \text{otherwise} \end{cases} \tag{6}$$

where z is the dependents per tourism worker, y is the other residents in region r, and H is the housing capacity.

The original conceptual models defined the relationship between visitation and ecological impacts as a limiting feedback loop due to loss of attractions and less shelter for campsites. However, a literature review of camper preferences (Daniels & Marion, 2006; Lawson & Manning, 2003) indicated that tourists are more responsive to changing levels of regulation than they are to environmental impacts. Following large declines in coral health, visitor numbers remained unchanged. A more likely impact on tourist numbers following ecological decline is greater regulation, particularly given the location of many campsites and popular tourist attractions in the Ningaloo Marine Park. Surveys of visitor preferences show that different visitor segments have different responses to greater regulation, with some disliking and others preferring a more regulated experience. This is captured by:

$$g = \begin{cases} g = gP_{sr}\,,\ i_r \geq i_{rw} \\ XYZ,\ \text{otherwise} \end{cases} \tag{7}$$

where i_r is the level of ecological impact, w is the threshold set by agencies managing natural resources, particularly in relation to protected areas and recreational fishing, and P_{sr} is the degree of impact that regulation has on visitor growth due to preferences of different visitors segments for each subregion. Changing the level of regulation therefore has an impact on the visitor mix.

Social impacts accumulate slowly and are slow to dissipate. Following events at Byron Bay, social impacts led to a cautious approach to tourism development, slowing accommodation and visitor growth. This is captured by:

$$S_r \Rightarrow A_r k \Rightarrow g_r k \Rightarrow 0 \tag{8}$$

where S_r is the social impacts index and k is the effects on accommodation and growth rate. S_r is a slow variable as it relates to impacts that change slowly, and balance each other.

The visitor mix in the region is affected by both accommodation mix and regulatory changes, which alter the size and proportion of visitor segments. The visitor segments were identified through factor analysis of visitor preferences for different experiences on the Ningaloo Coast, explained in more detail in Appendix E and in *Ningaloo Coast Region Visitor Statistics* (2009), a STCRC report available for download[3]. The factor analysis revealed three distinct groups with a number of significant results confirming their validity. The three experiences were: the comfortable visit, the nature lover, and the fishing escape.

Each segment has different patterns of activities and expenditure, which in turn drive the ecological and social impacts. Some groups can create impacts that decrease their own satisfaction. For instance, increasing numbers of fishing escapees can lead to greater regulation of fishing, which drives them away from the region. Some feedback loops are stronger than others, leading to changes in the proportions of visitor segments, and therefore patterns of activities and expenditures. Activities can take place in subregions outside of where visitors are staying. For instance, visitors to Exmouth predominantly snorkel in Cape Range National Park. Resident activities are also included through data gathered using resident surveys. Controls can be exerted on the system by changing the accommodation mix, the time and level at which regulation kicks, and the growth rate (g). The initial growth rate can be set by the NDM user, as it is difficult to predict how tourism will grow and develop, and a random growth rate leads to results that are difficult to interpret and therefore contribute less to learning. However, feedback loops will alter growth rates across model runs.

[3] http://www.crctourism.com.au/BookShop/BookDetail.aspx?d=720

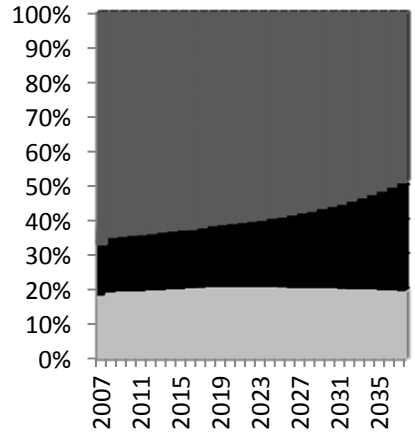

Figure 3.1: Proportional change in visitor segments in the region with the addition of 400 hotel beds at Gnaraloo Station (2007-2037).

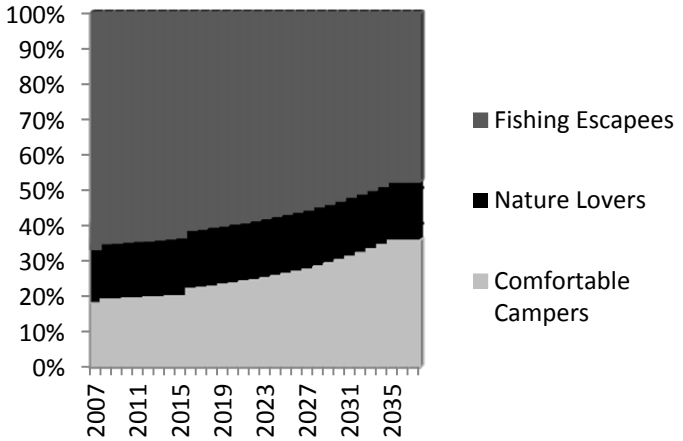

Figure 3.1: Proportional change in visitor segments in the region with the addition of 400 caravan beds at Gnaraloo Station (2007-2037).

The final set of outputs is linked to accommodation rather than to visitor segments, although visitor segments do have preferences for different accommodation types. Water and electricity data was collected directly from accommodation providers and through agreements with Horizon Power and the Water Corporation. Human

waste was calculated using figures for the average waste produced by humans. With the exception of electricity use in hotels, water and electricity were calculated using the nights in a particular accommodation type:

$$O_{rt} = \sum_{r=n}^{r} (N_{ta} o_a) \tag{9}$$

where *o* represents water use, electricity use with the exception of hotels, and waste generation and *O* is total resource use for region *r* at time *t*. Data on electricity use in hotels indicates that they use largest amounts of electricity during the off-season when visitation is at its lowest due to the high temperatures in the Australian summer. Electricity demand in hotels was relative to the season *t* and the accommodation capacity *A*

$$Q_t = \sum_{r=n}^{r} (Aq_t) \tag{10}$$

where Q is total electricity used by a hotel and q is the electricity used per bedroom in season *t*.

4. RESULTS:

The Ningaloo Destination Model (NDM) was run to test the differential impacts of two accommodation options at Gnaraloo Station, the first being the addition of 400 caravan park beds, and the second being the addition of 400 hotel beds. In both cases the model runs assumed the extra beds would be added in 2016 and the site would be operating at full capacity. Campgrounds were artificially capped at their 2007 level so that growth in visitors staying in campsites would not distort the specific impacts of extra caravan park and hotel beds. Growth rates were also set substantially higher for nature lovers and comfortable campers as they start from a low base in the region, and they are the groups with strong preferences for caravan parks and hotels. Growth rates for fishing escapees was set at 0.1%, since this group is already very large (see figures 2 and 3), and they dislike infrastructure such as sealed roads and toilets (as indicated through our visitor surveys, Jones *et al.*, 2009). The results from the two model runs are discussed below. The social impacts of the NDM discussed in the previous chapter are not discussed here as they are specific to the town sites where the communities reside.

The visitor mix in the region changes substantially with the advent of new accommodation. Adding 400 new hotel beds to Gnaraloo increases the proportion of nature lovers visiting the region from 14% in 2007 to 32% in 2037, while the proportion of comfortable campers rises only slightly in the same timeframe (Figure 3.1). In contrast, adding 400 caravan park beds to Gnaraloo switches this relationship, with the proportion of comfortable campers increasing from 17% in 2007 to 36% in 2037, and nature lovers remaining relatively steady on 18% (Figure 3.2). Because both model runs cap campsite numbers in 2007, growth in the proportion of fishing escapees is limited. This group actually shrinks in size in both scenarios because of the feedback loop which has fishing escapees avoiding areas that become more regulated in response to growing visitor numbers, and because of competition from other groups. In the NDM, the variation between visitor segments and the accommodation they stay in drives impact patterns around Gnaraloo Station. The 400 hotel bed scenario generates more visitor nights than

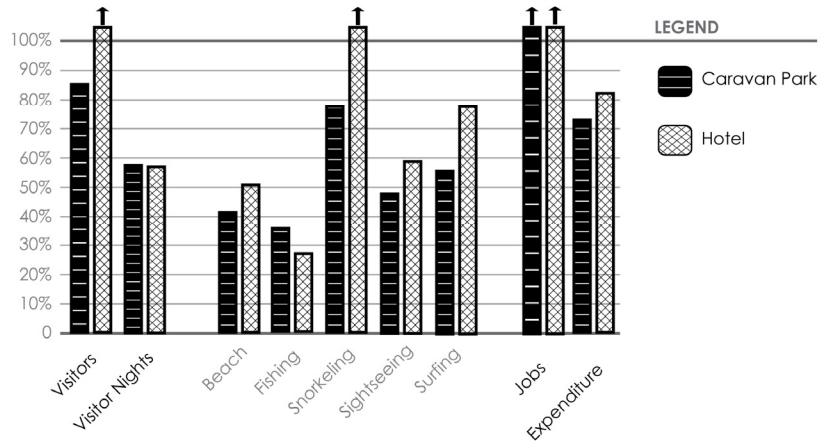

Figure 4: Comparison of tourism and economic impacts in the Ningaloo Region caused by adding 400 caravan park beds versus 400 hotel beds to Gnaraloo station (percent change from 2007-2037).

400 caravan park beds; however, because hotel visitors on average have shorter stays in the region, a hotel requires more visitors than a caravan park to generate a comparable number of visitor nights. Thus, the difference in visitor nights between the two runs at t=30 is less than one percent.

The influence of accommodation types becomes apparent when examining the activity-effort of visitors. Figure 4 compares impacts of the two scenarios on visitor activities by 2037 (t=30). The hotel scenario generates more beach, snorkelling, sightseeing, and surfing activity; whereas the caravan park scenario generates more fishing activity, reflecting the greater desire of visitors who stay in caravan parks to fish compared to visitors who stay in hotels. In both runs snorkelling is the activity that increases the most (107% by 2037 for the hotel scenario, 79% for the caravan park scenario).

110% 107%

Figure 4 also compares the relative impacts of the two scenarios on jobs and visitor expenditure by 2037. Although the hotel scenario has a stronger positive impact in job generation and visitor expenditure, the difference in expenditure is not as great as would be expected in other locations. This is because some Ningaloo visitors, particularly backpackers and Australians on extended self-drive holidays, will stay in caravan parks while still spending money on activities such as whale shark tours. In both scenarios, campgrounds are displaced by the other forms of accommodation, driving up the average nightly expenditure. The hotel scenario creates the greatest increase in nightly spend: 15% to $63.75 by 2037.[4] While the additional jobs hotel brings have positive social impacts, it also means more residents on the pastoral stations, who bring their own resource and environmental impacts (all of which are included in the results).

The positive impacts of the hotel scenario in terms of jobs and expenditure need to be weighed against a hotel's greater demand for resources (Figure 5). Water requirements of a hotel are substantially greater than a caravan park. By 2037, the hotel scenario results in a 258% increase in water demand on pastoral stations, versus a

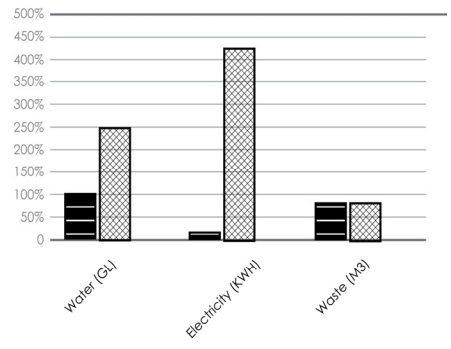

Figure 5: Comparison of resource impacts on Ningaloo pastoral stations, caused by adding 400 caravan park beds versus 400 hotel beds to Gnaraloo station (percent change from 2007-2037).

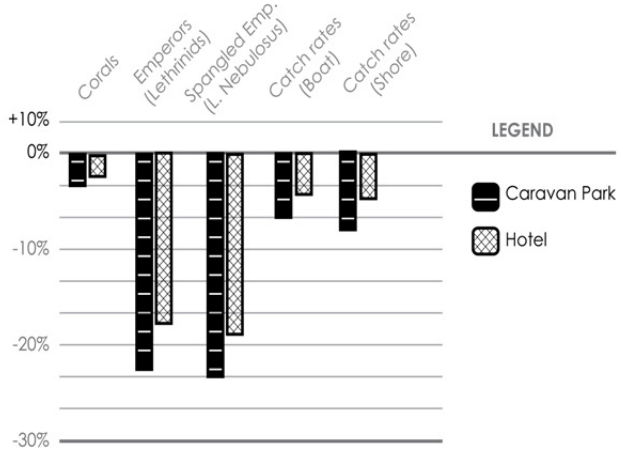

Figure 6: Comparison of ecological impacts on the Ningaloo region, caused by adding 400 caravan park beds versus 400 hotel beds to Gnaraloo station (percent change from 2007-2037).

[4] It should be noted that the expenditure figures do not take CPI increases into account (in other words, they are in 2007 dollar values).

100% increase for the caravan park scenario. However, the greatest difference is in electricity demand, with a hotel driving an electricity use up 400% over 30 years. It should be noted that the figures used in these model runs are based on existing practices. It is possible that future developments could be required or encouraged to reduce their power and water demand, thereby reducing the size of their impact.

Ecological impacts for the two scenarios (Figure 6) were generated using the CSIRO's Ningaloo-Exmouth Ecopath, with Ecosim model. In both scenarios, there are substantial reductions in fish stocks and catch rates. However, most of the fishing effort can be attributed to visitors staying in campsites, who, by 2037, still amount to over 69% of total visitors in both development scenarios. Nonetheless, the caravan park scenario has a distinctly greater impact on catch rates and fish stocks when compared to the hotel, with a respective 23% versus 17% reduction in emperor (lethrinid) stocks by 2037. This is due to greater fishing effort on the part of people who stay in caravan parks. Coral impacts are similar under both scenarios. Snorkelling is the most popular activity for all visitor segments, and therefore increases substantially with any type of accommodation expansion. Although snorkelling effort increases by a larger amount under the hotel scenario, this effect is buffered somewhat by the fact that hotels attract a greater proportion of nature lovers, who are more likely than other visitor segments to self regulate their snorkelling to minimise coral damage.

5. DISCUSSION AND CONCLUSION

There are tradeoffs in three primary areas when comparing a hotel and a caravan park in an environmentally sensitive and remote location like Gnaraloo Bay. First, the ecology of the area is better served by a hotel as its temporary residents are less disposed to extractive activities like recreational fishing. It would be possible, and probably more effective, to mitigate recreational fishing impacts through more restrictive fishing regulations, but these are politically unpopular and difficult to enforce. Additionally, hotel residents tend to take greater care around coral when snorkelling, although educational programs could improve self-regulation of snorkelling among caravan park guests. Second, hotels generate more tourist expenditure, driving growth in jobs and gross regional product. However, the expenditure difference between hotels and caravan parks is less marked in Ningaloo than other locations, due to the kinds of experiences that tourists are seeking in the region and the way that a lack of hotel beds across the region has pushed tourists into chalet and cabin accommodation in caravan parks.

Third, the resource requirements of a hotel are far greater than a caravan park, given current practices in the region. It is likely that remoteness and proximity to Ningaloo Reef will result in coastal developments having to provide their own water and electricity, and have stringent measures for disposal of waste including waste water. Provision of water on the west side of Cape Range is already a vexed issue, and there is little information about the quality of the water or the implications for Ningaloo Reef. Electricity is also an issue, with the most likely scenario being either diesel (current practice), or a mix of diesel as base load and renewable energy sources. Thus reductions in water, energy and waste requirements are important in these circumstances. Planning conditions for future accommodation could require limits on electricity use, water use and waste generated per visitor night. Developers could also be required to demonstrate how they would meet and monitor these conditions. Another option would be to reduce the size of development nodes, or experiment with the accommodation mix.

The first point in particular indicates the usefulness of multi-model projects due to the expansion of indicators if it is possible to integrate different models. Recreational fishing was confirmed through the Ningaloo Collaboration Cluster to have the largest impact on the ecology of the region, and through the modelling it was possible to explore the different ways that this can be managed without severe restrictions on the positive economic and social benefits, and the ways that future growth can contain the level of recreational fishing of additional visitors. While the ecological model generated a wider range of impacts for the NDM, the NDM connected the ecological model with land use planning and strategic tourism planning. Furthermore, the NDM was incorporated into the Ningaloo Invitro Model, a multi-sector model of the entire region that makes use of a variety of modelling techniques.

The dynamics of the NDM are determined by the choices of tourists within the model and the capacity constraints set by the model users. As such, the NDM moves away from the deterministic assumption that the dynamics of the TALC model will automatically apply to Ningaloo, while capturing important aspects identified by Butler. The visitor mix is central to the dynamics of both the NDM and TALC as visitor preferences drive changes in both. The NDM uses visitor preferences and the region's capacities to determine the dynamics of change. It is therefore possible, by choosing different levels and types of accommodation, to avoid the tourism "life cycle", which could be enhanced further through targeted marketing and regulatory changes. Capacities should not refer only to the site and its immediate surrounds in a tourism context; they should also address the tourists' activities, which drive both the positive and negative impacts on communities and the attractions that draw tourists to the region, and the tourists' resource use. It is important to focus on the capacities that slow and

alter regional tourism changes, such as: visitor accommodation, stricter regulatory regimes, residential accommodation, employee availability and social impacts. In particular, the NDM goes beyond TALC with regard to regulation, which protects the resource, but also drives changes in the visitor mix. In short it is not enough to assume that tourism "life cycle" will occur when it is possible to explore how capacity management can exert control over the future of a tourism destination.

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