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Contribution to the Special 'Managing flatback turtles for the future'

A focus on flatback turtles: the social acceptability of conservation interventions in two Australian case studies

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ABSTRACT: Human-induced climate change is a threat to marine species and ecosystems worldwide, including sea turtles. As climate changes are projected to intensify, directed management and intervention is required to safeguard the future of vulnerable species and ecosystems. Prioritisation tools that explore the cost–benefit–risk can help in the choice of interventions. However, an often-overlooked element underpinning the success of directed interventions is the extent to which they are perceived as acceptable by local communities (i.e. social acceptability). We assess the social acceptability for a range of adaptation interventions for flatback turtles *Natator depressus* (FBTs) in north-western Australia. A survey of residents in Port Hedland and Broome showed that FBTs are important to the identity of both towns and local FBT decline or extinction would have negative local social and economic impacts. In both locations, survey respondents expressed strong support for intervening to protect FBTs and there was broad agreement between respondents from both locations on the most and least acceptable interventions. For example, in both locations the most acceptable intervention was to restrict 4-wheel-drive beach access for locals and visitors and the least acceptable was to intervene genetically in the FBT populations. In the case of FBT conservation in Port Hedland and Broome, (1) interventions that limit human behaviour, as opposed to interfering with the species themselves, are likely to be most socially acceptable, and therefore (2) are also most likely to be implemented successfully and avoid conflicts within the community.

KEY WORDS: Adaptation · Climate change · Social acceptability · *Natator depressus*

1. INTRODUCTION

There are conservation threats for many species globally (Pacifici et al. 2020) and these threats are increasing because of the combined effects of coastal development (Fuentes et al. 2016), human population growth (Duarte et al. 2020), and climate change (Titeux et al. 2017). Conservation efforts have helped protect species against current threats, but there often remains a need to actively intervene (i.e. apply

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directed adaptation and conservation measures) to ensure vulnerable species persist into the future (Park et al. 2012). That is, conservation focussed management needs to be robust to also account for projected and future threats (Macinnis-Ng et al. 2021).

Coastal species are considered particularly vulnerable to beach-based impacts such as changing beach temperatures, shade availability, and overwash (Lockley & Eizaguirre 2021). Beach-based breeding species such as turtles and seabirds are well represented on national and international threatened species lists (Ward et al. 2021) because of beach-based impacts, including predation. Threats multiply at the coast, and for many coastal species there are limited locations that offer environmental conditions necessary for the survival of nestlings. Traditional conservation efforts have sought to minimise the exposure to anthropogenic threats, for example through the creation of protected areas and the protection or buffering of species from certain impacts through fencing, culling, and weeding. However, because of climate change, such traditional measures may not always be sufficient, and for many vulnerable species additional intervention may also be needed in various locales (e.g. both *in situ* and extra-local).

One such vulnerable coastal species, where interventions to enhance adaptation and long-term persistence are needed (Hamann et al. 2007) is the flatback turtle *Natator depressus* (FBT). FBTs are endemic breeders along the northern Australian coastal region (Pendoley et al. 2014), with foraging grounds known in the Indonesian archipelago and Papua New Guinea. FBT numbers have declined in the past, although there is also evidence of population recovery in some Australian locations (e.g. in Queensland; Limpus et al. 2020), and nesting success is variable across space and time (Thums et al. 2020). The main threats to this species in north-western Australia are (1) marine debris, (2) altered onshore and nearshore light conditions, (3) modification to beaches, (4) introduced animals (non-native predators), (5) sea level rise and (6) increasing temperature (beach and ocean) (Department of Biodiversity Conservation and Attractions 2017). The severity and influence of the threats differs spatially between coastal locations. For example, in some locations onshore or nearshore lights disorientate emerging hatchlings. In other locations both native and non-native animals are disturbing nests and eating turtle eggs (Truscott et al. 2017) and sometimes a number of threats occur together.

The geographical difference in threats means that management interventions that work in one location might not be as appropriate for others. Moreover, there are often multiple ways to address component threats. For example, replacing dark sand with lighter coloured, or changing sand composition to combat warming sand (Jensen et al. 2018, Mortimer 1990) might promote egg survival *in situ*, however, incubating eggs offsite may also achieve the same outcome in terms of the production of an equal number of, or more hatchlings (Bentley 2018). The economic cost and the technical feasibility of the various possible management interventions are also likely to differ between locations.

Conservation practitioners are tasked with determining which interventions are most appropriate and effective in these contexts and prioritising accordingly. Prior to implementation conservation practitioners need to carefully assess the economic costs, technical feasibility, and overall implementation risks. As a result, a range of intervention prioritisation tools have been developed that allow for cost–benefit–risk calculation comparisons (Hobday et al. 2015). However, alongside the technical aspects of interventions and associated costs, it is also important to consider social values and acceptability (Stankey & Shindler 2006). For example, community members 'know things differently' and often have important local information that can help inform intervention design and implementation (Caniglia et al. 2021). Community members and experts can help estimate implementation risk (Hobday et al. 2015). However, it can be more difficult for experts to estimate the social acceptability of different interventions (Tuohy et al. in press in this Special), particularly compared to the technical and economic aspects. Importantly, each community is unique (van Putten et al. 2017). Community members will have different conservation related norms, values and traditions, which will impact the social acceptability of the interventions. Ensuring that interventions are socially acceptable, therefore, is key because even if they are low cost and technically feasible — they may not be successful in their implementation if there is a lack of community support (Stankey & Shindler 2006).

Understanding community support for, and the social acceptability of, conservation interventions is therefore critical. By understanding the place-specific social acceptability of interventions, conservation professionals can better inform themselves about local preferences, management can prepare communities appropriately (e.g. tailor communication and engagement), and public money can be used wisely. Therefore, to support FBT management in northwest Western Australia we assessed community perceptions and social acceptability of different proposed FBT conservation interventions in 2 local communities (Broome and Port Hedland). These locations were selected as both have extant FBT breeding sites (Department of Biodiversity Conservation and Attractions 2017). We also included both communities to explore community level similarities and differences related to the social acceptability of different interventions. Using a survey, we assessed (1) the importance of FBTs to community members, (2) community member perceptions about the current management of FBTs in the region, and (3) the level of social acceptability of different intervention options.

2. METHODS

2.1. Case study description

In this research we use 2 case study locations (Broome and Port Hedland) and compare the social acceptability of different interventions. Comparative case study analyses can provide valuable practical knowledge for conservation (Flyvbjerg 2006). Broome and Port Hedland are located in northwest Western Australia, approximately 600 km apart (Fig. 1). Both communities have FBT nesting grounds on local beaches (Fig. 1, insert) and both are remote coastal Port Hedland has 15298 permanent residents and Broome has 14660, and slightly more male than female residents in total (Australian Bureau of Statistics 2021). Populations are relatively young, with the median ages being 31 yr in Port Hedland and 34 yr in Broome, whereas 38 yr is the Australian (and Western Australian) median age. Median weekly household income is higher in Port Hedland (AUD 3278) than Broome (AUD 2623), and both are higher than the Western Australian (AUD 2214) and Australian average (AUD 2120). The traditional Indigenous owners in the Port Hedland township are the Kariyarra people and in the Broome township, the

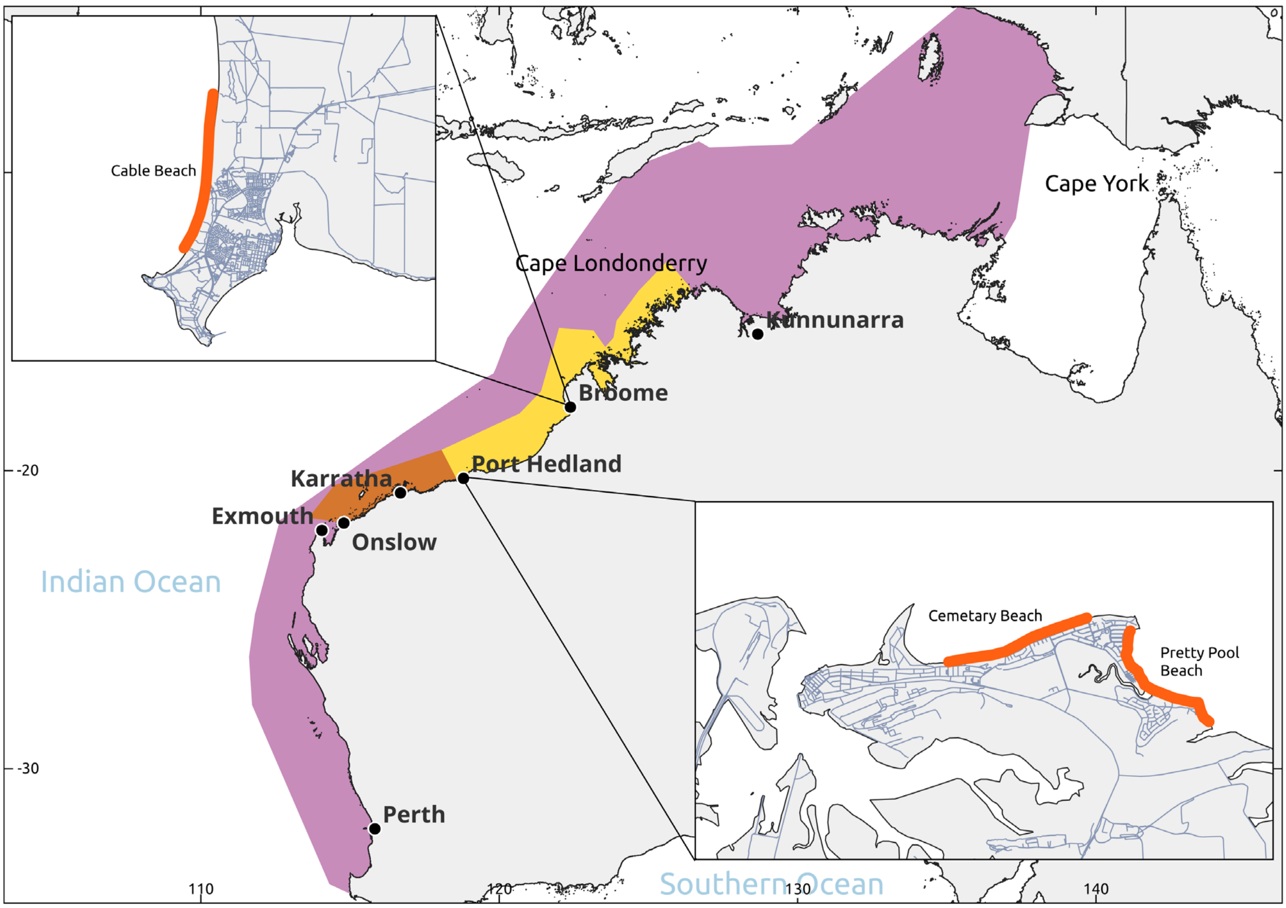

Fig. 1. Summer-nesting flatback turtles. Foraging grounds in mauve; North West Shelf stock in orange; reference stocks in yellow (image adapted from '[About the program] | [North West Shelf Flatbacks]', dbca.wa.gov.au). The location of the main turtle beaches in Port Hedland and Broome are also indicated

Yawuru people, who also hold Native Title for the area.

As regional Australian towns, these 2 places might seem similar, but they differ particularly in terms of the main economic activity. Port Hedland's economy is influenced by the mining industry with 22% of the population working in iron ore mining (compared with 2.5% of the population in Western Australia and 0.3% in Australia as a whole). Port Hedland also serves as an export port for mineral resources mainly to Asia. In contrast, the economy of Broome is mainly influenced by the tourism sector. The biggest employment segment in Broome is accommodation (5.7% of the jobs). These sectoral differences are also reflected in the main occupations: technicians and trade workers (25.3%) in Port Hedland, and professionals (20.6%) in Broome. In both places, a higher-than-average number of people work full time: 70.3% in Port Hedland and 64.4% in Broome (as opposed to 57.1% in West Australia) (Australian Bureau of Statistics 2021).

The local beaches where FBT nest are also quite different from each other. Cemetery Beach in Port Hedland faces north and is located approximately 1.2 km from the town centre (Table 1). The beach is around 1.3 km long and has a road between it and a strip of houses. The highest nesting density is located at the eastern end of the beach (Whittock 2019). At the eastern end of the beach is a hotel, and the western end adjoins the port. Care for Hedland Group (CHG) has been collecting information on FBTs since 2003 and continues to play an important part in the protection of FBTs in Port Hedland. CHG is quite active and has been responsible for developing a sheltered FBT interpretation area and an annual schedule of FBT related activities. A second nesting area, Pretty Pool Beach, faces north and is approximately the same length as Cemetery Beach. It is

Table 1. Beaches and flatback turtle (FBT) conservation activity in Port Hedland and Broome. Some population demographics also listed (obtained from https://www.abs.gov.au/census/find-census-data/quickstats/2021). WA: Western Australia; DBCA: Department of Biodiversity, Conservation and Attractions

	Port Hedland	Broome
Site information		
Beach name(s)	Cemetery Beach; Pretty Pool Beach	Cable Beach - Walmanyjun
Length	1.2 km; 1.2 km	22 km
Distance from town centre	1.2 km; 5 km	3 km
Local FBT activity	Care for Hedland Environmental Association (CFH) (Turtle monitoring)	Cable Beach community turtle monitoring program administered by DBCA
Restrictions in place	Reduced streetlights for turtle season. Torches/flashlights and flash photography are not allowed on the beach at night during turtle season. Closed to pets	Closed to cars in December and January. Access ramp closed 20:00–06:00 h daily from 1 December to 31 January, and for 2 h either side of high tides > 9 m
Estimated FBT population	148 to 202 individuals between 2009/10 and 2013/14 (Pendoley et al. 2014, Waayers & Stubbs 2016) 31 to 222 individuals between 2005/06 and 2013/14 (Whittock 2019)	10–100 FBT nests annually (DBCA 2017)
Population information		
Population size (2 660 026 in WA)	15 298	14 660
Gender distribution (49.7% male, 50.3% female in WA)	53.5% male, 47.5% female	48.5% male, 51.5% female
Median weekly household income (AUD 2214 in WA)	AUD 3278	AUD 2623
Median age (38 yr in WA)	32 yr	34 yr
Education to Bachelor degree level and above (23.8% in WA)	12.8%	21.7%
Full-time employment (57.1% in WA)	70.3%	64.4%

backed by a 200 m wide foredune, the area is further from the houses and urban development and is ~5km from the town centre.

Broome's Cable Beach faces west, is around 22 km long, and is approximately 3 km to the northwest of the town centre. FBTs nest on the northern end of the beach, which is separated from the southern end by a rocky area and is adjoined by natural vegetation. At times of the year when 4-wheel-drive (4WD) vehicles are allowed on the beach, the northern end is associated with high tourist activity. Beach cruising in a 4WD is a popular activity for local people and tourists. The southern beach is adjoined by several bars and restaurants and associated car parks.

We developed and implemented a community-based survey (hereafter called the 'community survey')[1] that was specifically aimed at permanent residents of Broome and Port Hedland and not, for instance tourists or the fly-in-fly-out mining workforce. We only focus on residents because they are directly involved with local conservation activities and monitoring, and they can potentially influence the types of activities that are undertaken. We recognise that because we specifically focussed on residents, we missed out on gaining insights from the people who pass through these locations (tourists) or are permanent resident elsewhere in Australia (i.e. fly-in-fly-out workers) who potentially have differing values and preferences for interventions.

We aimed to survey across all residents including members of the Indigenous community but we did not ask people about their Indigenous heritage in the survey. We felt that to gain meaningful insights from Indigenous groups would need a well-considered separate survey tailored specifically to this group, which should be a separate (future) research project. The community survey was developed in parallel to an 'intervention prioritisation tool' that we used with experts to investigate their views on interventions (reported in A. J. Hobday et al. unpubl.).

The community survey (see Supplement 1 at www.int-res.com/articles/suppl/n052p189_supp1.pdf) consisted of 6 sections in which we explored how much local residents agreed or disagree with statements regarding (1) the importance of FBTs to the community- and personal identity, (2) the authorities responsible for conservation, (3) management activities and their efficacy, (4) the main threats to local FBTs, and (5) intervening to ensure FBT conservation in the future and (6) 24 different interventions and their acceptability. For more detailed information on the 24 interventions included in the survey, see Table S1 in Supplement 2 at www.int-res.com/articles/suppl/n052p189_supp2.pdf. In the last section of the survey, respondents were also asked (in an open-ended question) to indicate which local intervention they would consider most important.

The survey finished with some standard demographic questions (e.g. age, education, length of residence in the area, gender). Most questions were on a Likert rating scale from 1 to 10, whereby a score of 1 would indicate that the respondent strongly disagreed with the statement, whereas a 10 indicated that the respondent strongly agreed with the statement. This scoring scale allows for confidence in interpretation since there is no mid-point (Cvitanovic et al. 2018, 2020, Tuohy et al. 2022), and therefore a score of 5 would indicate that the participant slightly disagreed with the statement they were presented with, and a score of 6 would mean that the participant slightly agreed with the final statement (Bryman 2012). Because there was no option for the respondent to indicate they felt 'neutral' or had 'no opinion' by not providing a midpoint, it was emphasised (in the introduction to the survey) that responses could be left blank, thus reflecting their not having an opinion (Johns 2005, Colman et al. 1997). Most approaches using Likert scales have drawbacks, which are discussed in the literature (see for instance South et al. 2022). We acknowledge that our approach introduces potential bias through forcing a choice to be made, although there is no *a priori* reason why the bias should be in one direction only.

2.2. Survey implementation

The implementation of the survey was carried out in accordance with human ethics approval from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Human Ethics Committee (protocol number 067/21). The voluntary online community survey was made available on SurveyMonkey™. The intention was to recruit residents in places where there was high foot traffic, such as shopping malls, piers, playgrounds, or fishing spots, following Cvitanovic et al. (2018) and Tuohy et al. (2022), and

[1]It is referred to as the 'Social Acceptability Survey' in other related papers but because we collect much more information than just social acceptability, we refer to it differently here.

then present them with iPads they could use to complete the survey. The link to the community survey was also available by scanning a QR-code on posters to allow respondents to complete the survey on their own phone/device, or later if they so desired. A paper version of the survey was also available as an alternative to the computer-based technology.

A 4-person research team first visited Port Hedland and attempted to recruit people in the previously mentioned areas. However, there was very low survey participation, in part due to continuing COVID-19 concerns. Additional recruitment, using snowball sampling, was achieved using an equivalent online survey via a link that was distributed post hoc through local turtle management groups/authorities; the CHG in Port Hedland, and the regional Broome hub for the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA).

A SurveyMonkey function was implemented to limit participation to 1 survey per IP address. We also used the date stamp on survey responses to check for patterns in responses over time. The survey took between 15 and 30 min to complete. A total of 48 surveys were obtained for Port Hedland and 47 for Broome. Incomplete surveys with missing demographic data were excluded, resulting in 42 useable surveys included in the analysis for each location.

2.3. Data analysis

Data were analysed using descriptive statistics to assess respondents' perceptions against the study aim (to understand community support for, and the social acceptability of conservation interventions). Analysis was performed in R (version 4.1.2) and 1-way ANOVA tests were applied to determine whether there were any statistically significant differences in question scoring between Port Hedland and Broome. In doing so we acknowledge the ongoing discussion as to whether Likert data should be considered as ordinal or interval for the purposes of analysis and reporting (Göb et al. 2007). We acknowledge that the sample size of 42 for each location is small given the size of the communities (Table 1), which limits the strength of our conclusions. In addition, we used the non-random snowball sampling technique (also referred to as judgment, selective, or subjective sampling) which means our study also has limited generalizability (see Section 4).

3. RESULTS

3.1. Demographics

The survey respondents predominantly identified as female (76% in Broome and 79% in Port Hedland); 5% identified as non-binary, other, or preferred not to say. The average ages of male and female respondents in Broome were 44 and 45 yr , respectively; and 42 and 38 yr in Port Hedland, respectively . The youngest respondents were 19 yr of age and the oldest was 71. Local residency averaged approximately 10 yr in both places, with the longest being 70 yr in Broome and 60 yr in Port Hedland (the shortest was 1 mo). Education levels were higher for females than males. In Port Hedland, 25% of females had a Bachelor's degree or higher (compared to 4% for male respondents in Port Hedland). More respondents in Port Hedland reported having a certificate or Assoc diploma (14%) than in Broome (7%). Nine of the respondents in Port Hedland (roughly 20%) indicated they were members of the CHG, and 10 respondents in Broome (roughly 24%) indicated they were active volunteers in the Cable Beach Turtle Monitoring group.

We want to highlight that our sample is small and where we relate the results to some of the demographic characteristics (see Tables S2 & S3 in Supplement 2) these may be unrepresentative of the broader population in the 2 case study locations (e.g. a high number of female versus male survey respondents).

3.2. Responsibility and management

One of the questions we sought to answer via this survey was about the importance of the FBT to residents of both towns. Survey respondents suggested that FBTs are important to their town's identity (mean scores 9.255 in Port Hedland and 9.149 in Broome) and that their local extinction would have negative social and economic impacts in their towns (mean scores 8.851 in Port Hedland and 9.043 in Broome). There was no statistical difference between respondents from the 2 towns ($p = 0.7601$ and 0.6343, respectively) in their reported perceptions of the importance of FBTs as per their responses to questions 1 and 2.

Not only are FBT important to both towns but respondents strongly agree they are also of personal importance to them (mean scores 8.62 in Port Hedland and 8.68 Broome). Again, there was no statistical difference between respondents from Broome and Port Hedland in the importance of the FBT to their residents ($p = 0.870$). Respondents strongly agreed that local FBT extinction would have a negative personal impact in both towns (mean scores 8.34 in Port Hedland and 8.53 in Broome). Females rated the importance of turtles more highly than male respondents (p = 0.0138) at a personal level (9.03 and 7.94, respectively).

We also asked survey respondents about their views on government and management. When asked who was responsible for FBT management, respondents primarily identified local government (95% and 93% of respondents in Port Hedland and Broome, respectively) closely followed by the community (93% and 90% in Port Hedland and Broome, respectively). In both places, 75% of respondents indicated that they (themselves) were also responsible for the management of FBTs. The only notable difference in answers across towns was that fewer respondents in Port Hedland (49%) identified FBTs as being the responsibility of the Federal Government than in Broome (74%).

In terms of confidence in the management of FBTs, respondents in Port Hedland (mean score 6.68) had more than in Broome (mean score 4.98) (Table 2). Port Hedland respondents also reported greater resident engagement in FBT conservation (mean score 6.60) than respondents from Broome (mean score 6.00) (Table 2). On average, Broome respondents were less confident that FBTs were well managed (score is less than 5, p-value = 0.001). Respondents from both communities indicated that government funding for FBT conservation and management in the region was inadequate (scores of less than 5).

Respondents with education up to technical training agreed more strongly that there was adequate funding for FBT conservation and management (4.62 and 3.65 respectively; see Table S2).

3.3. Threats and interventions

There was a strong indication that all threats to FBTs were perceived as major. Based on the scoring range of between 1 and 10, the top quarter of the range (scores over 7.5) may be considered high, which was true for all 6 threats in both Broome and Port Hedland (Table 3). The threat of marine debris received the highest score in both groups (9.37 in Broome and 8.91 in Port-Hedland). Light pollution was perceived to be a significantly greater threat in Port Hedland than in Broome (where it was perceived to be the lowest threat level).

Light was considered a greater threat by females than males (8.48 and 6.64 respectively). Marine debris were considered the greatest threat by female respondents (9.28) and climate change was considered the greatest threat by male respondents (8.57) (Table S2).

The interventions all address or respond to different threats (but sometimes they address more than one). For example, exterminating feral animals would address the threat posed by predation from animals introduced to the Australian natural environment (e.g. foxes, pigs, rats). Prohibiting 4WDs on the beaches near the nesting sites would address the threat of modification to beaches.

Results show that both groups of respondents strongly agreed that active intervention would be required to ensure the protection of FBTs into the future (mean score 8.72 in Broome and 8.76 in Port Hedland). Respondents in Broome more strongly agreed that these interventions have to be undertaken now (i.e. in the short term) (mean score 9.02 in Broome and 8.78 in Port Hedland) but the difference between the 2 groups of respondents was not statistically significant. Female respondents more strongly agreed that the interventions had to be undertaken in the short term (9.16) than male respondents (7.93) (Table S2).

On average, responses suggest that the interventions were more acceptable to respondents from Broome than Port Hedland (mean scores 7.16 and 6.66, respectively). There was general agreement among respondents from both communities regarding

Table 2. Mean ± SD score (1 = strongly disagree; 10 = strongly agree) for knowledge and adequacy of management activities according to residents in Broome (n = 42) and Port Hedland (n = 42). Statistical difference calculated using 1-way ANOVA test; **p ≤ 0.01

	Broome	Port Hedland	Difference (p)
Awareness of management measures in place to protect FBTs	6.21 ± 2.63	6.92 ± 2.59	0.209
Confidence that FBTs are well managed	5.00 ± 2.28	6.68 ± 2.55	0.001**
Adequacy of government funding into FBT conservation and management	4.64 ± 2.53	3.80 ± 2.31	0.115
Adequacy of information on the management of FBTs	7.96 ± 2.07	7.12 ± 2.71	0.098
Engagement in the management of FBTs	6.00 ± 2.93	6.60 ± 2.32	0.270

Table 3. Mean ± SD score (1 = no threat at all; 10 = major threat) for the perceived threats to FBTs according to residents in Broome (n = 42) and Port Hedland (n = 42). Coloured shading indicates perceived degree of threat importance; listing order is based on Broome respondents. Statistical differences calculated using 1-way ANOVA test; *p ≤ 0.05

Threat category	Broome	Port Hedland	Difference (p)
Marine debris	9.37 ± 1.35	8.91 ± 2.13	0.231
Coastal development[a]	8.93 ± 1.65	8.13 ± 2.43	0.767
Modification to beaches	8.51 ± 1.90	8.73 ± 1.84	0.579
Climate change	8.21 ± 2.09	8.55 ± 2.18	0.465
Introduced animals	7.74 ± 1.95	7.76 ± 2.22	0.980
Sea level rise	7.63 ± 2.49	7.68 ± 2.23	0.915
Altered onshore and nearshore light conditions	7.54 ± 2.46	8.55 ± 1.96	0.039*

[a]This threat is not explicitly mentioned by DBCA (2017) but it was asked in the survey

the most and least acceptable interventions (Table 4). For example, in both locations the most acceptable intervention was to restrict 4WDs on the beach (9.17 in Broome and 9.45 in Port Hedland) and the least acceptable was to intervene genetically so females breed earlier and more often (3.82 in Broome and 3.42 in Port Hedland). These were also the only interventions that had a score greater than 9 and less than 4, respectively. There were significant differences in the scoring between the 2 locations only for 3 of the interventions ($p < 0.050$). For example, respondents in Broome indicated that reducing disturbance by restricting beach and water activities within a 5 km radius of the nesting beach was more acceptable (8.29) than those in Port Hedland (7.00). Broome residents also indicated 2 other interventions that were more acceptable than in Port Hedland: flushing stomachs (7.81 and 6.39 respectively) and aiding natural selection (7.49 and 6.44 respectively).

The respondents from both places scored the same 5 interventions as less acceptable (score less than 6) (see Table 4). Harvesting predatory fish living under jetties in order to reduce predation of hatchlings had low acceptability among respondents from both locations (4.83 in Broome and 4.76 in Port Hedland).

Even though responses from both groups suggest that exterminating feral animals in/around nesting areas (Table 4) is an acceptable intervention, there was dispersal of scores around the mean in both locations (standard deviation > 3). In Port Hedland there was also high dispersal of scores around the mean score (standard deviation > 3) in the acceptability of collecting hatchlings directly from the nest and transporting them offshore, and people guarding nests during the hatching season (Table 4).

The respondents were asked to score the interventions which we subsequently ranked according to the scoring (Table 4). There were some differences between the 2 locations in terms of the relative ranking of the interventions, but the difference was small. First, collecting eggs from beach and incubating offsite was ranked 4th lowest in Port Hedland and 7th lowest in Broome. Second, excluding feral animals from nesting areas was ranked 2nd highest in terms of average score by respondents from Port Hedland and it had the 4th highest average score among respondents in Broome (Table 4).

We might expect there to be some differences in the acceptability scoring according to different respondent demographics (see Supplement 2 for details of gender, age, length of residency and education level). Because some demographics (e.g. gender distribution) do not reflect the broader population we hesitate to draw large inferences. However, some notable differences can be drawn out. For example, male respondents scored the overall acceptability of the interventions lower than females. Residents who had lived longer (≥5 yr) in the case study locations also gave overall lower acceptability scores than those who had not (<5 yr). While there were few notable differences in the rank order of the interventions according to residency, male respondents indicated that cooling turtle nests with shading was most acceptable and harvesting predatory fish living under jetties least acceptable (but they perceived seasonal fishing bans as more acceptable than female respondents). The acceptability scoring by respondent age (older and younger) and education (up to technical training or university) did not appear to vary much.

When respondents were asked (in an open-ended question) which intervention would have the greatest impact on turtle conservation for their area many different suggestions were made. In Port Hedland respondents indicated that protecting the FBTs from 'people' was important but suggestions around reducing light and controlling feral animals to 'moving egg to quieter beach' and reducing plastics and pollution were also important. Among Broome respondents the most important intervention was prohibiting 4WD access to FBT nesting areas. A common intervention mentioned in both Broome and Port Hedland was increasing public awareness of the

Table 4. Mean ± SD acceptability (rank in brackets) for 24 different conservation interventions for flatback turtle populations in Broome (n = 42) and Port Hedland (n = 42) on a scale of 1 (completely unacceptable) to 10 (totally acceptable), with both lists ordered according to the Broome ranking from 1 (most acceptable) to 24 (least acceptable). Colouring of the cells indicates scoring: dark brown <4, brown <5, orange <6, pale green <7, light green <8, green < 9, dark green >9. Statistical difference calculated using 1-way ANOVA test; *p ≤ 0.05

Intervention (short description)	Broome	Port Hedland	Difference (p)
Prohibit 4WD activity from nesting areas	9.17 ± 1.77 (1)	9.45 ± 1.57 (1)	0.435
Improve condition of feeding grounds (away from Port Hedland) by banning dredging	8.93 ± 1.57 (2)	8.15 ± 2.12 (4)	0.062
Protect areas where female flatback turtles feed (e.g. from fishing and dredging)	8.78 ± 1.88 (3)	8.29 ± 2.26 (3)	0.291
Exclude feral animals from nesting areas (e.g. fencing out pigs and foxes)	8.66 ± 2.25 (4)	8.69 ± 2.12 (2)	0.947
Turn lights off on jetties and ships during hatching season (where safe to do so)	8.42 ± 1.87 (5)	8.07 ± 2.16 (5)	0.441
Treat turtles with infections and diseases (e.g. removing tumours)	8.48 ± 1.77 (6)	8.00 ± 2.06 (6)	0.262
Impose seasonal fishing bans in areas where adult turtles are present	8.44 ± 1.80 (7)	7.88 ± 2.03 (7)	0.190
Reduce disturbance by restricting beach and water activities within a 5 km radius of the nesting beach	8.30 ± 2.04 (8)	7.00 ± 2.50 (10)	0.012*
Impose seasonal fishing bans in areas where juvenile turtles are present	7.93 ± 2.05 (9)	7.51 ± 2.00 (8)	0.357
Flush the stomachs of large flatback turtles to remove large plastics	7.81 ± 2.11 (10)	6.39 ± 2.71 (13)	0.010*
Aid natural selection by focussing protection on early maturing (less than 20 yr) turtles and their nests to increase population	7.49 ± 2.11 (11)	6.44 ± 2.06 (12)	0.026*
Exterminate feral animals in/around nesting areas (e.g. shooting or poisoning)	7.39 ± 3.05 (12)	6.31 ± 3.08 (15)	0.112
People guard nests during hatching season and guide hatchlings to the waters edge	7.54 ± 2.47 (13)	6.95 ± 3.04 (11)	0.340
Cool turtle nests with shading using canopies of solid canvas or mesh	7.20 ± 2.36 (14)	6.36 ± 2.83 (14)	0.147
Enhance beach depth (e.g. with sand nourishment) to reduce salt water flooding of nests	7.00 ± 2.57 (15)	7.45 ± 2.16 (9)	0.387
Move eggs or nests to location on the same beach where hatching success is higher	6.55 ± 2.70 (16)	5.95 ± 2.91 (17)	0.338
Collect hatchlings from the water's edge and transport them offshore to avoid predators	6.42 ± 2.51 (17)	5.69 ± 2.87 (18)	0.225
Collect eggs from beach and incubate offsite	6.12 ± 2.55 (18)	5.38 ± 2.80 (21)	0.212
Cool individual nests with electrical equipment to hatch both males and females	5.76 ± 2.87 (19)	5.54 ± 2.78 (19)	0.916
Replace dark beach sand with light sand to lower nest temperature to hatch both males and females	5.60 ± 2.61 (20)	5.54 ± 2.78 (20)	0.233
Use excavation equipment to improve the density of the sand (i.e. for nesting purposes)	5.41 ± 2.50 (21)	6.10 ± 2.61 (16)	0.233
Collect hatchlings directly from the nest and transport them offshore to avoid predators	5.30 ± 2.85 (22)	4.45 ± 3.12 (23)	0.203
Harvest predatory fish living under jetties to minimise hatchlings being preyed upon	4.83 ± 2.50 (23)	4.76 ± 2.64 (22)	0.912
Intervene genetically so females breed earlier and more often (e.g. via gene editing)	3.816 ± 2.54 (24)	3.415 ± 2.50 (24)	0.481

threats faced by FBTs. However, there were some contrasting views about increasing signage. While some respondents suggested that this would raise awareness and positively change people's behaviour towards FBTs, others replied that signage and nest marking could have unintended negative outcomes, such as attracting vandalism.

4. DISCUSSION AND CONCLUSION

The need for increased efforts to secure the conservation of biodiversity and vulnerable species is clear and many threats to conservation have accelerated with climate change (Ward et al. 2021). Reducing the threats to biodiversity will require human behaviour change (Díaz et al. 2015). It will also require careful and innovative thinking about new opportunities for management interventions or new ways of implementing them (Bowgen et al. 2022). Community support, or social acceptability, of these new and innovative conservation interventions will be key to the success of implementation, particularly if associated human behaviour changes are required.

In our study of 2 communities in Western Australia, many respondents indicated high support for interventions intended to conserve the FBT. There was a general agreement between respondents from Broome and Port Hedland that these interventions should be implemented now. The need for short term interventions may be a reflection of local decline in FBT populations (Waayers & Stubbs 2016). It could also be indicative of a more general global trend due to the increase in pressures on the natural world (Hobbs et al. 2011). The Federal Government in Australia has recently recognised that innovative approaches to halt biodiversity decline are required in the 2023 'Strategy for Nature' (https://www.australiasnaturehub.gov.au/national-strategy).

Implementing effective conservation management interventions requires collaboration between government, local communities, and additional stakeholders (Nielsen et al. 2021). Conservation practitioners are more likely to come up with appealing and workable interventions if they recognize the multitude of community views and values that can influence on-ground actions (Kendal & Ford 2018b) and build trust with the local people (van Putten et al. 2022). Working together and developing trust within communities is likely to have a positive influence on conservation outcomes (Armitage et al. 2020).

Community support for, and social acceptance of interventions that are implemented at the local scale will contribute to the ultimate success of local conservation activities (Niemiec et al. 2020). Support for local management interventions can be encouraged by learning about community perceptions, wants, and needs, and employing tailored approaches to communication, education, and engagement activities for awareness raising (Cvitanovic et al. 2021). Unfortunately, raising awareness may not guarantee positive conservation outcomes and misplaced conservation efforts can still result (Ford et al. 2021). Support for intervening in the natural world cannot be automatically assumed (Kilpatrick et al. 2017). Strongly opposing views exist about the value of intervening to safeguard the natural world (Van Meerbeek et al. 2019). Thus, integrating information about local communities into conservation planning, determining community support for local interventions (in our case FBT conservation) and encouraging social acceptance of different interventions can contribute to successfully managing a threatened species.

Survey respondents from Broome and Port Hedland indicated strong support for interventions to safeguard the long-term survival of FBTs. Importantly they also recognised that they themselves are agents of change. They indicated that if the FBT is going to survive and thrive in the future, this is not only the responsibility of the local government and community groups, but it also lies in the hands of the local people/guardians (as residents indicated in the survey) highlighting the importance of local empowerment and action. It should be noted, however, that respondents deemed financial support from central government agencies as being insufficient in this case and adequate support by higher level agencies was important for FBT survival. Locally operated NGO groups can support management and build local confidence in management activities. Community empowerment is important for facilitating successful conservation actions, especially when communities are remote, and local NGOs need to be supported to ensure long term conservation success.

Our initial survey with respondents from the 2 communities in northwest Western Australia suggests agreement on some issues. For example, there was strong agreement on the most acceptable potential interventions (banning 4WDs, protection of feeding areas, and excluding feral animals from critical beach areas) and least acceptable interventions (intervene genetically, harvesting predatory fish, and collecting hatchlings directly from the nest to transport them offshore). Our results suggest that interventions that limit human behaviour, as opposed to interfering with the species themselves, are more socially acceptable in this comparative case study, and therefore are also more likely to be implemented successfully and avoid conflicts within the community. Consensus among stakeholders can positively affect the success of management interventions implemented decision making (Thiault et al. 2021). Commonalities and shared perceptions of acceptability across communities could facilitate management and potentially reduce implementation costs. Moreover, data that reflects recognition of strong community support for certain interventions — such as banning 4WDs from nesting beaches — can diffuse concerns about implementation and assist in local communication campaigns. However, because our sample size is small there could be a potential bias, so more research is needed to confirm this.

A noteworthy point of alignment between respondents from both communities was the view that genetic modification for conservation was unacceptable. This suggests that respondents and perhaps others in this area of Australia may be ethically uncomfortable with such actions or that they might lack confidence about genetic intervention (Mankad et al. 2021), even though such options may have transformative potential in the long run. This result provides an opportunity to engage with concerns and misconceptions among members of the public (e.g. building related scientific literacy), before considering implementing genetic interventions.

Projects can fail if they are not properly tailored to context and community and the importance of social acceptability cannot be underestimated (Kendal & Ford 2018a). Overestimating social acceptability can threaten conservation interventions through a lack of community support and potentially divisive local resistance. Similarly, underestimating local acceptance can mean that some simple interventions get overlooked (or unjustifiably considered too risky) by conservation practitioners.

In presenting our results we acknowledge that there are several shortcomings. Firstly, Indigenous people in Australia have important, diverse relationships and cultural connections with Australian flora and fauna (Leiper et al. 2018). These connections, as well as recognition as Native Title holders, means they play a critical role in conservation (Gadgil et al. 1993). While Indigenous respondents may have been among those who participated in our project, we made no distinct or targeted efforts to invite Indigenous participation. Ideally, a project such as ours would centre on the key roles of Indigenous people in the area, and include their perceptions of the FBT and conservation interventions. Such efforts should be included in any expansion of this project, and in similar projects. We also acknowledge the multiple problems and inaccuracies that occur in survey work. For example, involving people in a survey will mean some 'strategic' answers and socially motivated misreporting might apply (Vesely & Klöckner 2020). Even though our sample sizes were adequate for analysis, our snowball recruitment strategy likely introduced potential bias towards people who are concerned about conservation. The respondents cannot be assumed to represent the opinions of the larger community. A larger sample size and different recruitment strategy is needed to make inferences about the entire community. Lastly, we chose a quantitative survey approach which does not gain the rich insights that can be obtained in interviews (and qualitative approaches more generally).

Conducting this research reveals that even in places that are similar in size and in the same region of a country, perceptions and values can both converge and diverge (e.g. calling for tailored education/outreach programs or slightly different combinations of conservation interventions based on levels of local acceptability). This knowledge is meaningful to management to understand community attitudes and the deployment of the interventions. Moreover, collecting community data on the acceptability of interventions may be a worthwhile investment that will have a positive payoff in the longer term.

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