Vol. 53: 1–12, 2024
https://doi.org/10.3354/esr01283

ENDANGERED SPECIES RESEARCH
Endang Species Res

Published January 18

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

Social acceptability of conservation interventions for flatback turtles: comparing expert and public perceptions

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ABSTRACT: Sea turtles are facing significant threats, including anthropogenic warming, predation from feral animals, and sea level rise. While a range of intervention options are available, resource constraints and increasing time pressures means managers face the difficult task of prioritising options. To achieve successful conservation outcomes, managers are increasingly seeking to understand the social acceptability, as well as biological plausibility and economic feasibility, of these intervention options. Previous studies have used expert opinion as predictors of social acceptability, given their technical knowledge and experience implementing the interventions; however, the assumption that the social acceptability of interventions is the same for both the general public and experts is largely untested. We tested this assumption using surveys to assess the social acceptability of 24 interventions proposed for a population of flatback turtles *Natator depressus* in northwest Australia. Survey responses were collected from community members (residents) and experts (resource managers and researchers). Experts were asked to provide their own opinion of acceptability and how they perceived community members would rate intervention options. In general, residents ranked interventions that directly intervene with human behaviour or the environment as more acceptable than those that directly target turtles, while experts tended to favour direct turtle interventions. Experts incorrectly predicted that the community would not be influenced by the target of the intervention. Our findings highlight the importance of understanding social acceptability of interventions before implementation to inform management decisions and engagement and communication strategies, particularly when interventions might be controversial or restrict human behaviour directly.

KEY WORDS: *Natator depressus* · Decision-making · Conservation · Public participation · Marine species · Adaptation

1. INTRODUCTION

Marine species and ecosystems are facing significant threats globally from climate change, pollution, fishing pressure, and modification to marine and coastal areas, among others (Halpern et al. 2008). To date, this has resulted in significant changes to the physiology and phenology of many marine species (Doney et al. 2012), shifts in the composition and distribution of marine species and ecosystems (Pecl et al. 2017), and reduced marine ecosystem functioning (Beaugrand et al. 2010). With the increasing frequency and severity of extreme events resulting from anthropogenic climate change (e.g. marine heat-

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waves), the impacts on marine species and ecosystems are projected to intensify. In combination, these impacts have had, and will continue to have, significant socio-economic consequences for society (Madin et al. 2012, Pecl et al. 2017, Nash et al. 2022).

The need to develop adaptation options for marine species and ecosystems is being increasingly recognised (e.g. Creighton et al. 2016, Hobday et al. 2018). Here, adaptation refers to 'the process of adjustment to actual or expected climate and its effects, [...] to moderate or avoid harm or exploit beneficial opportunities' (following IPCC 2014, p. 76). Adaptation can be autonomous (i.e. species responding to change without human intervention, Pecl et al. 2019) or directed (i.e. involving human intervention). However, anthropogenic pressures in marine ecosystems, as well as the rapid rate of climate change, limits the potential for autonomous adaptation in many species, and instead necessitates more directed intervention approaches. These directed interventions can take a variety of forms, with a target species often having multiple intervention options that can contribute to either incremental or transformative change (Park et al. 2012). Likewise, some intervention options may be simple and generally accepted in practice (e.g. habitat restoration), while others may be more novel and perceived as riskier (e.g. breeding programmes or genetic modification).

Given limited resources (e.g. funding and time), managers and practitioners face the difficult task of prioritising which intervention option(s) to implement. Several prioritisation tools have been developed to assist decision-makers to explore the cost–benefit–risk of different options (see Hobday et al. 2015b). However, to achieve successful conservation outcomes, these decisions should ideally be informed by scientific evidence that accounts for and integrates different economic and social perspectives (Cornell et al. 2013). As such, managers are increasingly seeking to understand the social acceptability, as well as biological plausibility and economic feasibility, of these intervention options (Bennett 2016). Social acceptability is defined here as a process by which individuals judge alternatives and decide the extent to which they are favourable (Brunson & Shindler 2004). As described by Stankey & Shindler (2006), acceptability judgements can be shaped by an individual's underlying value system. This value system is a culmination of an individual's technical and personal knowledge, institutional and personal trust, risk and uncertainty, and the spatial, temporal, and social context (e.g. Ajzen & Fishbein 1980, Brunson & Shindler 2004). This unique value system means that predicting how an individual may view a choice or situation is difficult.

Failure to acknowledge and consider the social acceptability of intervention measures can lead to unsuccessful implementation, irrespective of scientific rigour (Bennett et al. 2017). However, evaluating social acceptability of intervention options presents several challenges for managers and practitioners. Measuring the social acceptability of management and conservation initiatives in each community requires significant financial, human, and time resources. As such, social acceptability is seldom considered ahead of the implementation of a management intervention (Hobday et al. 2015a). Furthermore, in cases where social acceptability is considered or accounted for, it has typically relied on the perspective of either experts or community members, with few evaluating or comparing the acceptability reported by both groups (Ban et al. 2009). Given that individual interests and concerns are often situated in specific, local-scale contexts, previous research suggests that relying on expert perceptions of social acceptability interventions may provide an incomplete picture (i.e. it is difficult to know how each community will react) (Stankey & Schindler 2006). Thus, a more holistic understanding of social acceptability within a given context may contribute to a better understanding of the social impacts of an intervention, assist in identifying areas in which strategic engagement and communication efforts may be required if that intervention is applied, and improve the necessary social license for practitioners and managers to directly intervene (Young et al. 2013, Kelly et al. 2017).

Here we focus on conservation of the flatback turtle *Natator depressus* in northwest Australia to assess potential variation in the social acceptability of management interventions among scientists and local residents. We asked experts and residents of 2 coastal communities to evaluate the social acceptability of possible interventions to protect flatback turtles. We also asked the experts to predict how they expected the residents to evaluate the interventions. While our focus is on the management of flatback turtles, the study design and findings have implications for managers and practitioners developing adaptation plans and considering intervention options for marine species elsewhere.

2. MATERIALS AND METHODS

2.1. Study species

The flatback turtle *Natator depressus* is endemic to Australia (Pendoley et al. 2014). Feeding sites for flatback turtles have been documented in the northern coastal regions of Australia, extending as far south as the Tropic of Capricorn, and extending into the Indonesian archipelago and the Papua New Guinea coast (FitzSimmons et al. 2020). These turtles are facing significant threats resulting from marine debris, onshore and nearshore light, modification to beaches, introduced animals, sea level rise, and increasing temperature. Nationally, flatback turtles are listed as 'vulnerable' under the Environment Protection and Biodiversity Conservation Act 1999 and are listed as Data Deficient on the IUCN Red List (Red List Standards & Petitions Subcommittee 1996) as a result of a lack of long-term population demographic data. In some locations, nesting beaches are close to population centres where residents may value or ignore their presence during breeding seasons.

2.2. Study sites

Community surveys occurred in 2 major settlements in Western Australia: Port Hedland and Broome. These coastal urban centres are approximately 600 km apart and relatively remote from other towns. Port Hedland has a recorded resident population of 15298 people, while Broome has a resident population of 14660 people (Australian Bureau of Statistics 2021). Both communities are known for their proximity to large turtle rookeries, with flatback turtle nesting sites located on local beaches in or near the primary town precincts. Although Port Hedland and Broome are both regional Australian towns, they differ in terms of the primary economic activity. Port Hedland serves as a major export port of mineral resources, with 22 % of the population working in the iron ore mining industry. In comparison, Broome has a thriving tourism industry and is popular for its picturesque beaches and opportunities to interact with wildlife (e.g. turtles).

The beaches where flatback turtles nest differ in each town. Cemetery Beach in Port Hedland faces north and is located approximately 1.2 km from the town centre. 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 et al. 2014), where a hotel is located. The western end adjoins the port. The Care for Hedland community group has been collecting information on flatback turtles since 2003 and plays an important part in the protection of flatback turtles in Port Hedland. They have been responsible for developing a flatback turtle interpretation area and an annual schedule of flatback turtle-related activities. In comparison, Cable Beach in Broome faces west, is around 22 km long, and is approximately 3 km to the northwest of the town centre. The flatback turtle nests are on the northern end of the beach, which is separated from the southern end by a rocky area. The southern beach area adjoins several bars and restaurants and associated car parks. The northern end, where flatback turtles nest, is adjacent to natural vegetation. The Cable Beach Turtle Monitoring Group in Broome is a program whereby volunteers monitor turtle activity in the area during peak months. Four-wheel driving on the beach is a popular activity in Port Hedland and Broome, although it is restricted on relevant beaches during turtle nesting season.

2.3. Study design

First, we developed a list of management interventions specific to flatback turtles based on a review of sea turtle conservation literature and experience in designing conservation interventions (e.g. Hobday et al. 2015b) (see Table S1 in the Supplement at www.int-res.com/articles/suppl/n053p001_supp.pdf). In total, 29 management interventions were listed, all of which aimed to improve the population status of turtles (e.g. shaded nests to change hatchling sex ratio). Each intervention was relevant to a stage of the turtle lifecycle (e.g. some interventions focus on adults, others on juveniles or eggs). The interventions also affected turtle vulnerability to a threat in different ways. The interventions were categorised according to whether they directly impacted (restricted or changed) the behaviour of people (e.g. banning 4-wheel driving [4WD] on beaches) or directly impacted the turtles (e.g. genetic manipulation or shading of the eggs). To ensure a common understanding of the interventions, a short description of the intervention alongside a picture and references from the literature was made available to experts and the public.

Two separate surveys were developed for community members and experts as part of different studies (see van Putten et al. and A. J. Hobday et al. unpubl.), and as such, the surveys differed slightly in their design and implementation. However, both studies sought to explore social acceptability of management interventions, among other things. To explore the social acceptability of identified management interventions among community members, a quantitative survey was developed and distributed to residents in Broome and Port Hedland. Quantitative survey methods were selected over qualitative to explore social acceptability among a larger number of individuals across several user groups. The survey instrument was developed following similar community surveys conducted elsewhere in Western Australia (e.g. Cvitanovic et al. 2018, Tuohy et al. 2022).

A Likert scale was used to measure social acceptability of the intervention options. Respondents were asked to indicate how acceptable they found each of the interventions using a 10-point scale. Two anchoring cues were provided on the Likert scale, whereby 1 represented 'completely unacceptable' and 10 represented 'totally acceptable'. This scoring scale allows for confidence in interpretation, since there is no midpoint (i.e. a score of 5 indicates the participant found the intervention slightly unacceptable, and a score of 6 indicates the participant found it slightly acceptable) (Bryman 2016). Respondents were able to leave a response blank if they did not want to indicate a preference. The survey was pilot-tested with 3 individuals who had previous experience conducting quantitative community surveys. Based on feedback, 5 intervention options were excluded from the survey instrument, as they were deemed too similar for community members to differentiate. This also reduced the length of the survey and addressed survey fatigue concerns reported by the pilot testers. The survey was then imported into the digital platform Survey Monkey for distribution.

A separate survey was developed for the experts to elicit both the perceived social acceptability of interventions to the community as well as the experts' personal rating of the acceptability of the management interventions. The same management interventions that were presented to the community were also provided to the experts for consideration. The expert survey contained several other questions (and some additional interventions) not further reported here. The qualitative rating scale for the experts was a 3-point value scale (low, medium, or high). The 10-point scale used in the community survey was converted (collapsed) into the same 3-point scale as the expert survey for data analysis (see Section 2.5).

2.4. Data collection

Community surveys were conducted *in situ* in Port Hedland and Broome (Western Australia) from 4 to 9 April 2022 by 4 members of the research team (P. Tuohy, R. Annand-Jones, C. Cvitanovic, and I. van Putten) . Data were collected through random, voluntary response sampling in areas with high foot traffic in Broome and Port Hedland, such as shopping centres and popular beaches. Respondents had the option of completing a paper copy of the survey or a digital copy of the survey either on a supplied device (an iPad) or their personal device (via a QR code). Given low response rates for in-person sampling, the link to the online survey was also distributed post hoc through snowball sampling (Goodman 1961). It was shared digitally with environmental community groups in Port Hedland and Broome, including Care for Hedland and the Cable Beach Turtle Monitoring Club.

Experts associated with the management and conservation of flatback turtles in Western Australia were identified and invited to complete a survey. Participants were identified through 'purposive sampling', whereby experts who had knowledge of and/or experience with marine management were selected. The experts included turtle programme managers, field officers, biologists, and interdisciplinary researchers. Respondents were emailed the survey tool by a co-author (A. J. Hobday) and asked to complete the tool and return it for analysis and interpretation. The expert tool was developed in Microsoft Excel 2010 in August 2021.

2.5. Data analysis

Our analysis compared (1) the experts' rating of the acceptability of management interventions, (2) the experts' perception of the community's acceptance, and (3) the community's own rating of the acceptability of management interventions. Bayesian methods were used to look for evidence that experts and community residents differed in how they assessed potential flatback turtle interventions, and whether experts' expectations on how residents would assess the interventions were accurate.

Data from the community surveys and the expert survey were collated and 'cleaned', with incomplete survey responses removed. All responses to the questions exploring the acceptability of the 24 interventions were converted to a 1, 2, or 3 scale. Where experts scored 'low' (on the qualitative 3-point scale), this was the equivalent of a score of 1, 2, or 3 by the community (on the 10-point Likert scale). An expert score of 'medium' was considered equal to a score of 4, 5, 6, or 7 by community members, and an expert score of 'high' was considered equal to a community score of 8, 9, or 10. As the choice of how we converted the 10-point resident scale to the 3-point expert scale could have impacted our findings, we also analysed other plausible mappings; however, we found that in all cases, our general conclusion remained unchanged (Table S2, Fig. S1).

Each intervention was coded as either directly targeting the turtles themselves (direct), or impacting turtles indirectly via limiting human activities in some way or modifying the turtles' environment (indirect), as acceptability of an intervention was expected to be influenced by the target of the intervention. We also expected that experts and residents might differ in their response depending on the target (e.g. residents may be less accepting of interventions that restricted their access to beaches or the activities they could perform on beaches) (Table S1).

The final data set was composed of 96 respondents (11 experts, 85 residents), each scoring the acceptability of up to 24 interventions using a 3-point scale. Experts were associated with their own scores and also the scores they perceived would be provided by residents. Four covariates were assigned as follows: x_i (i = X, E, B or P). Specifically, interventions were coded as either having direct impact on turtles ($x_X = 1$) or indirect impact ($x_X = 0$). Respondents were either experts ($x_E = 1$) or residents ($x_E = 0$). Residents were either associated with Broome ($x_B = 1$) or Port Hedland ($x_B = 0$). For each question, experts additionally had a score they perceived would represent residents ($x_P = 1$), or their own response ($x_P = 0$). The statistical model fit to these data was a mixed effects ordinal regression. In addition to the 4 fixed effects, it also included 3 random effects. The first random effect accounted for variation in the overall acceptability of each intervention, and the other 2 accounted for variation in typical scores provided among each of the experts and the residents, respectively.

Let $\Pr(y \mid i, j, x_X, x_E, x_P, x_B)$ be the predicted probability that respondent j provides a response score of y when assessing intervention i and the response is described by the predictors (x_X, x_E, x_P, x_B), This probability is calculated by first calculating the logit cumulative probabilities:

$$\text{logit}\Pr(y \le k \mid i, j, x_X, x_E, x_P, x_B) = \beta_{0,k} - \mu_{i,j}(x_X, x_E, x_P, x_B) \quad (1)$$

where k = 1 or 2, and

$$\begin{aligned}\mu_{i,j}(x_X, x_E, x_P, x_B) = \\ \beta_X x_X + \beta_E x_E + \beta_P x_P + \beta_B x_B + \\ \beta_{XB} x_X x_B + \beta_{XP} x_X x_P + \beta_{XE} x_E x_X + \\ \delta_i + x_E \varepsilon_j + (1 - x_E)\bar{\varepsilon}_j.\end{aligned} \quad (2)$$

Here, we have allowed statistical interactions between the focus of the intervention (indirect and direct) and the 3 remaining fixed effects, which provides flexibility in the predicted responses consistent with the observed data. The δ_i is a random effect associated with the intervention and is drawn from a normal distribution with mean zero and standard deviation σ_I. Similarly, ε_j and $\bar{\varepsilon}_j$ are random effects describing variation among experts and residents, and are normally distributed with standard deviations σ_E and σ_R, respectively.

Model parameters were estimated using Bayesian methods, and uninformative priors were considered so that the posterior distributions were dominated by the data. The model was coded and fit to the data set using the stan language in R (package 'rstan'). Two Monte Carlo Markov chains of length 1000 with a burn-in of 500 iterations were generated, and chain conversion was checked visually. The fitted model included estimates for all deviations associated with the random effects, which allowed us to rank the interventions in terms of acceptability and test a number of claims.

3. RESULTS

Broome residents completed 42 community surveys, and Port Hedland residents completed 43 surveys; interventions were also rated by 11 experts. The community respondents were predominantly female (76% in Broome and 79% in Port Hedland), and a small proportion of respondents did not identify their gender (5 and 2%, respectively). Nine of the respondents in Port Hedland indicated they were members of the Care for Hedland group, and 10 respondents in Broome indicated they were active volunteers in the Cable Beach Turtle Monitoring group.

Posterior parameter estimates and their associated uncertainty are presented in Table 1, and Bayesian credibilities associated with claims regarding differences in scores between groups are presented in Table 2. Perhaps not surprisingly, we found strong evidence of greater variation in reported scores among residents than among experts (i.e. $\sigma_R > \sigma_E$) (Table 2, Claim 1), that is, there was more disagreement in responses among residents than among experts. Port Hedland and Broome residents returned similar mean acceptability scores (Fig. 1, Claim 2). Both Port Hedland and Broome residents were both less accepting of interventions that directly impacted turtles (Fig. 1, Claims 3 and 4). In contrast, experts were more accepting of interven-

Table 1. Description of the parameters associated with the ordinal regression, their median estimate, and uncertainty. CI: credible interval; SD: standard deviation

Parameter	Description	Mean estimate	95 % CI
$\beta_{0,1}$	Breakpoint between responses 1 and 2 (logit)	−2.349	[−2.908, −1.662]
$\beta_{0,2}$	Breakpoint between responses 2 and 3 (logit)	2.221	[2.080, 2.357]
β_B	Change in acceptability for Broome residents compared to Port Hedland residents	0.299	[−0.315, 0.887]
β_X	Change in acceptability when intervention directly impacts turtle activities	−1.073	[−1.825, −0.380]
β_E	Change in acceptability for experts compared to residents	−2.800	[−3.336, −2.207]
β_P	Change in acceptability for residents when perceived by experts	1.522	[1.036, 2.028]
β_{XB}	Interaction between intervention type and Broome resident	0.366	[−0.024, 0.747]
β_{XE}	Interaction between intervention type and expert	2.315	[1.759, 2.911]
β_{XP}	Interaction between intervention type and perceived responses	−1.148	[−1.877, −0.414]
σ_I	Between-intervention variation (SD)	0.746	[0.553, 1.043]
σ_R	Between-resident variation (SD)	1.223	[1.015, 1.523]
σ_E	Between-expert variation (SD)	0.455	[0.219, 0.870]

Table 2. Credibilities associated with 10 claims regarding between-respondent variation in scoring, and mean acceptability scores between both respondent types (residents, experts), how experts perceive residents, and intervention groupings (indirect, direct). Credibilities are defined as the proportion of times the claim was satisfied when calculated from posterior parameter estimates (1000 were randomly generated). Thus, credibilities near 1 and 0 imply the claim was nearly always, or nearly never, supported by the data, respectively

Claim	Credibility
1. Between-resident variation > between-expert variation	0.998
2. Broome resident mean score > Port Hedland resident mean score	0.926
3. Port Hedland resident: mean score (direct) > mean score (indirect)	<0.001
4. Broome resident: mean score (direct) > mean score (indirect)	0.023
5. Expert, self: mean score (direct) > mean score (indirect)	0.998
6. Expert: mean score (self) > mean score (perceived for resident)	<0.001
7. Expert, perceived resident: mean score (direct) > mean score (indirect)	0.570

tions directed towards turtles (Fig. 1, Claim 5). Experts perceived that residents would be more accepting of interventions than their own acceptance (Fig. 1, Claim 6). Interestingly, experts incorrectly predicted that the target of the intervention would not, on average, impact their scoring of the intervention (Fig. 1, Claim 7).

Next, we used the model to estimate mean acceptability scores for all 24 interventions for both resident groups. Both groups ranked the interventions very similarly (Fig. 2). For example, 'exclude 4WD activity near colonies' was ranked as the most acceptable intervention, and 'genetic modification' was ranked as the least acceptable intervention, for both Port Hedland and Broome residents.

Similarly, we estimated mean acceptability scores for all 24 interventions for the 11 experts according to their own scoring and how they perceived residents would score. In this case, the rankings between the experts' own perceptions and how they perceived residents would respond were quite different (Fig. 3). On average, experts found interventions directly impacting turtles, such as managing disease and translocation, more acceptable than those that modified the turtle's environment (e.g. modifying beaches and culling predatory fish). Interestingly, experts ranked interventions differently to the resident groups (cf. Figs. 2 & 3). Furthermore, the experts' perceptions of residents were quite different from the resident groups' rankings (cf. Figs. 2 & 3). While there are some similarities (e.g. 'exclude 4WD activity from colony areas' was ranked highest by resident groups and the experts' perceived rankings), there are differences between expert's perceptions of residents and resident groups in the ranking of other interventions (cf. Figs. 2 & 3).

4. DISCUSSION

4.1. Actual acceptability of intervention options

Overall, the results show that experts and residents differed in how they tended to rank the

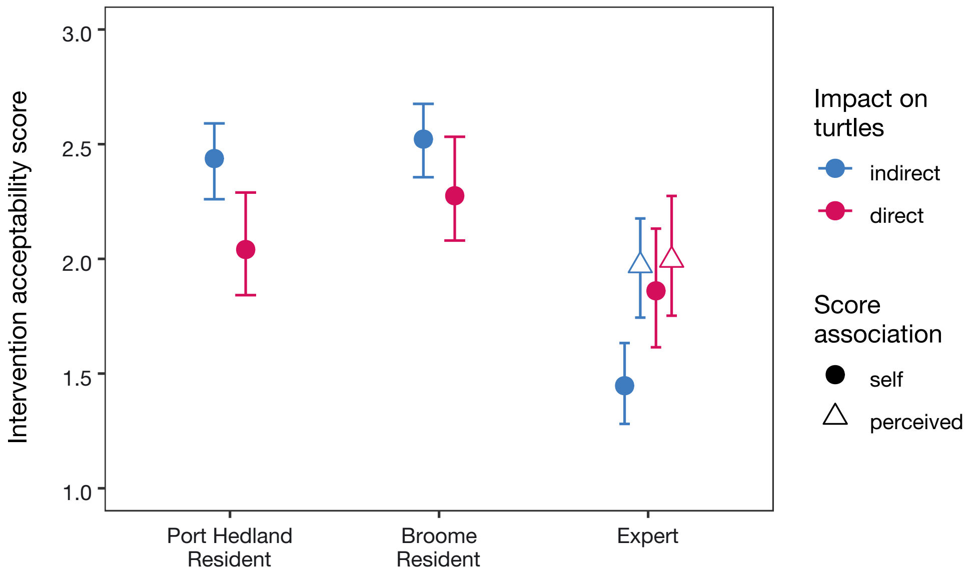

Fig. 1. Mean acceptability scores estimated by the ordinal regression and 95% credible intervals. Scores are colour-coded according to whether the associated intervention either directly impacts turtles (direct), or potentially restricts human access to beaches or modifies the turtle environment (indirect). Scores are presented for resident responses collected from Port Hedland and Broome. Two sets of scores are presented for experts: their own scoring (self) and how they expect residents to score (perceived)

acceptability of interventions. Other studies have found a similar divergence between experts and residents through surveys. For example, Ressurreição et al. (2012) found a divergence between experts' and residents' opinions of drivers of change, pressures, and management priorities in marine environments in the Azores archipelago, emphasising the importance of involving the public and stakeholders in marine management. Hobday et al. (2015a) found that the social acceptability of adaptation options for iconic species differed between experts and the public in an unpredictable way. However, there is limited research that explains the reasons for the variation between experts and residents in their acceptance of actions. Furthermore, there is little existing research which identifies potential reasons why experts may either find interventions less acceptable, or alternatively, why experts may score more conservatively. One potential explanation may be that, given their knowledge and experience in implementing management interventions, experts are more likely to understand the level of effectiveness of the intervention in conserving turtles as well as the risks and impacts associated with implementing each of them. However, further research is required to understand what factors influence an individual's acceptance, and whether these differ between experts and residents as this current research suggests.

Here, residents typically scored the acceptability of interventions that directly impact human activities higher than indirect interventions that target the turtles. Previous research has highlighted that motivating behavioural changes in communities (e.g. through direct interventions) is not without its challenges. For example, implementing new regulations that restrict activities in ocean and coastal areas can be met with non-compliance and conflict within communities (e.g. Iacarella et al. 2021). As such, it was expected that community acceptance of interventions that directly impacted turtles but would not require residents to change (or restrict) their behaviours would be higher. However, the results here show that this was not the case, and instead the community respondents indicated they were more willing to change their own behaviour than for management to prioritise interventions that impact the natural way of things (i.e. interventions that impacted the turtles directly, like transporting hatchlings offshore or incubating eggs offsite). In comparison, experts scored the acceptability of direct and indirect interventions in the opposite way to the residents, where experts ranked direct interventions less acceptable. This variation in the experts' and residents' reported acceptability of the interventions may be a result of the way that value systems and knowledge dictate an individual's level of acceptance (or lack thereof). For example, previous re-

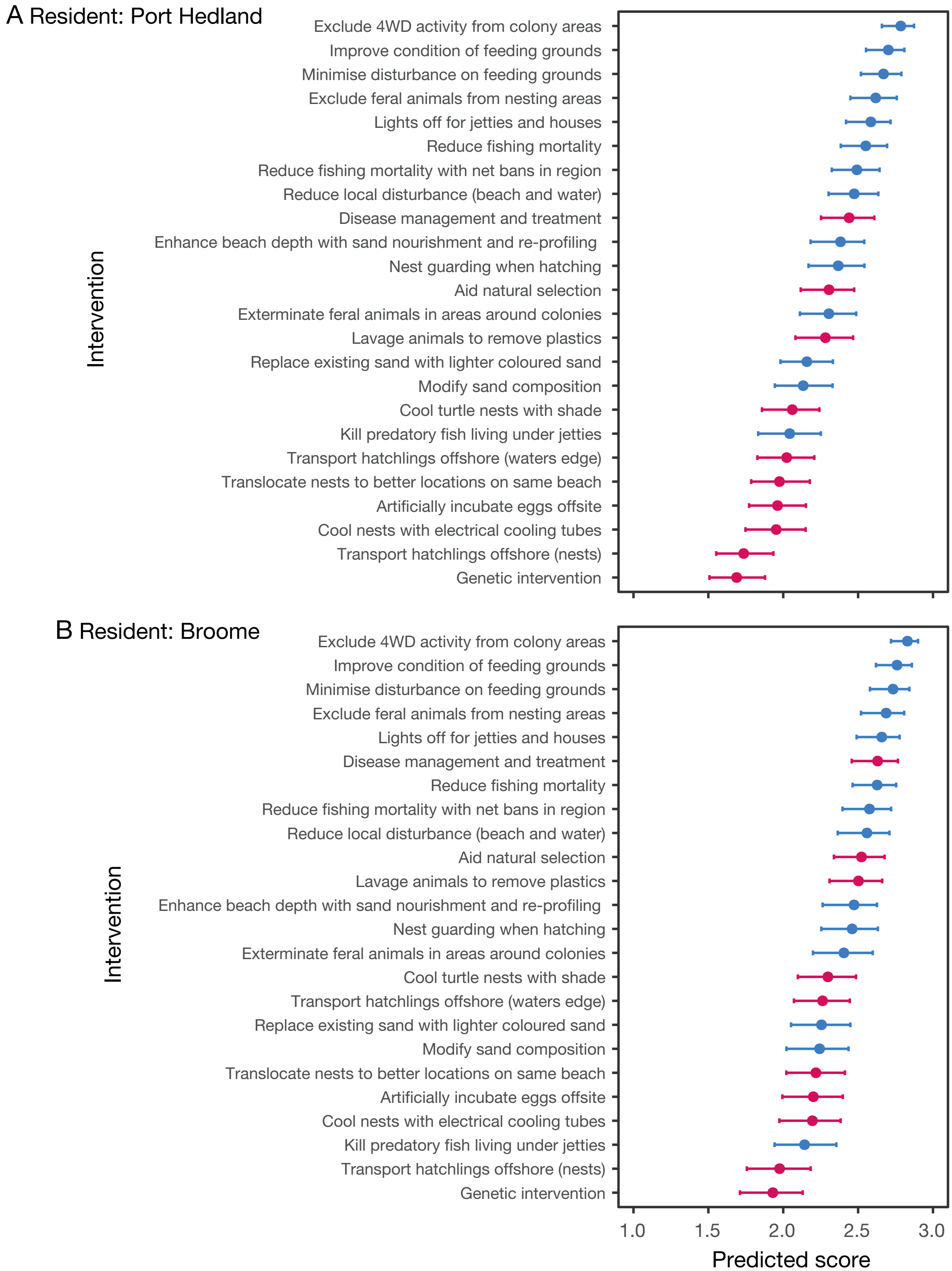

Fig. 2. Predicted mean acceptability scores and 95% credible intervals for both resident groups: (A) Port Hedland and (B) Broome. Scores are color-coded according to whether the associated intervention directly impacts turtles (red) or potentially restricts human access to beaches or modifies the turtle environment (blue)

search on koala management options has also found that differences in underlying environmental values and human–wildlife relationships are useful in explaining contrasting opinions between experts and the public (Drijfhout et al. 2022). In the case of flatback turtles, the experts surveyed here have a technical scientific background so may be able to understand and conceptualise the implementation of direct

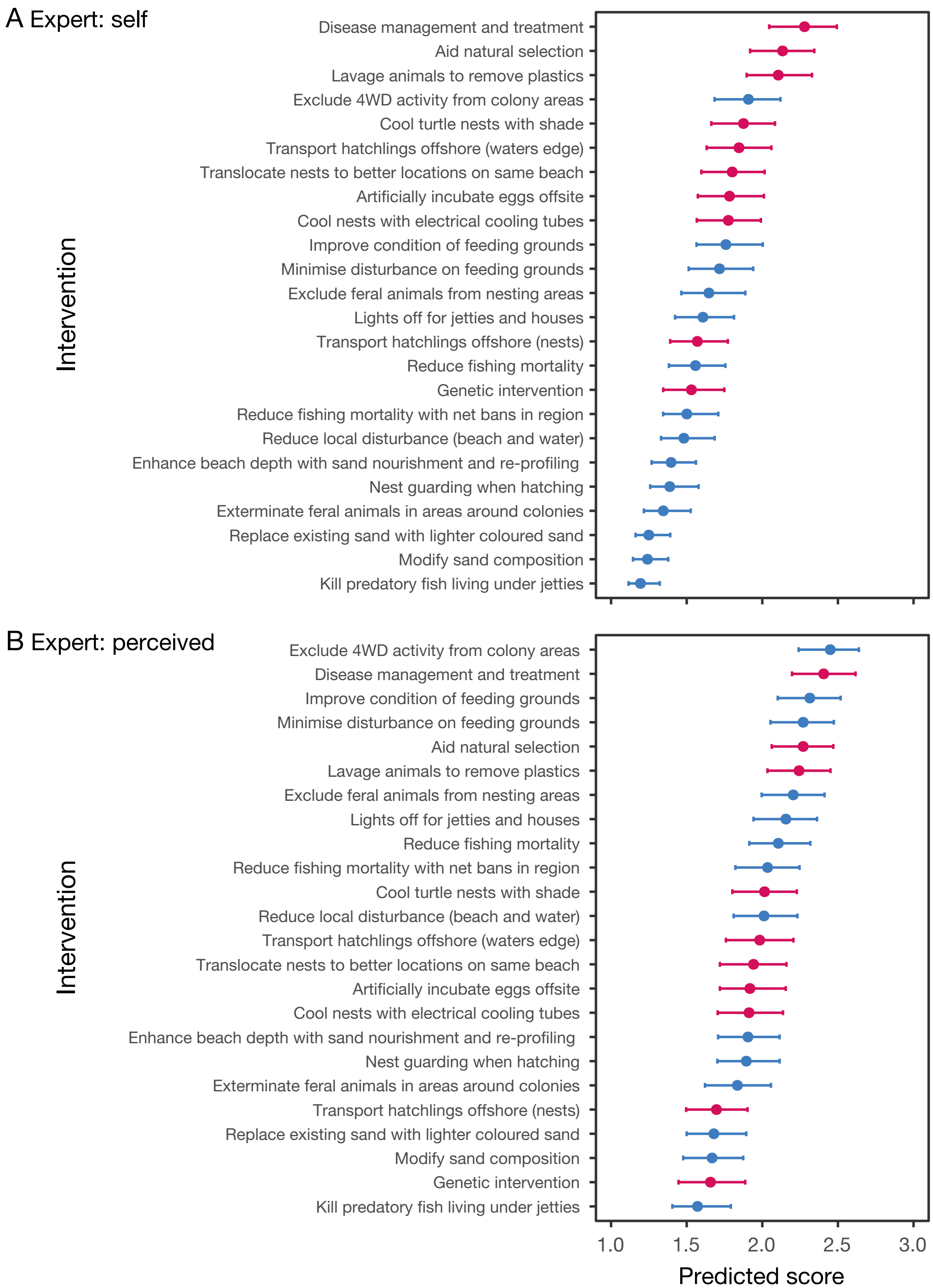

Fig. 3. Predicted means and 95% credible intervals for intervention scores for the experts. Rankings are provided for (A) experts' own perceptions and (B) how experts perceived residents would respond. Scores are color-coded according to whether the associated intervention directly impacts turtles (red) or potentially restricts human access to beaches or modifies the turtle environment (blue)

interventions better than the indirect interventions. In comparison, the community's perception of acceptability may be based more on their local contextual knowledge and close connection to the flatback turtles rather than on their technical knowledge of the direct interventions, and therefore they may be able to better conceptualise indirect interventions such as those that require behavioural changes.

Regarding the within-respondent group variation, the results show that there was more disagreement in responses among residents than experts, even after accounting for the effect of sample size. This aligns with previous research on community perceptions and attitudes showing that communities are not an amalgamation of homogeneous stakeholder groups but are instead a complex mix of identities and value systems (Voyer et al. 2015). Furthermore, communities are more likely to have varied expertise and opinions on marine management interventions in comparison to experts, potentially basing their perception of acceptability more on their value systems and experiences rather than on their technical knowledge. Interestingly, there were no significant differences between Port Hedland and Broome residents. This may be surprising, given that the economic focus (i.e. mining in Port Hedland and tourism in Broome) and population characteristics are somewhat different, and research indicates that community attitudes and acceptability are typically local and context specific (Stankey & Schindler 2006). However, both settlements are regional, remote communities in northwestern Australia with similar population sizes, and there may be enough similarity between the 2 communities of Broome and Port Hedland in terms of the value that turtles contribute to their community (see van Putten et al. 2023) to result in minimal variation in social acceptability between the 2 towns. Although their economies are driven by different industries, both communities have strong connections to flatback turtle populations, as is evident, for example, by the consistent work and many hours of volunteer time contributed by local community groups to maintain local turtle populations (e.g. see Care for Hedland 2022).

4.2. Perceived acceptability of intervention options

Experts expected that the residents' scores, on average, would be unaffected by the target of the intervention. However, experts believed that their own ranking of acceptability would differ from that of residents. One potential reason for this variation between perceived and actual acceptability is the influence of availability bias (Catalogue of Bias Collaboration 2019). Individuals that have strong feelings towards interventions that restrict their behaviour (e.g. banning 4WD vehicles on the beaches to ensure turtle conservation) may be likely to be more vocal, and therefore experts may subconsciously make their judgement based on the availability, or recall, of this information. Another potential reason why experts underestimated the acceptability of conservation interventions may be due to underestimating the community's connections to important species or ecosystems (e.g. local values, knowledge, and relationships), particularly for those stemming from indigenous epistemologies. This finding, in particular, has important implications for the management of flatback turtles in the northwest region. If experts perceive that residents find direct interventions less acceptable than they do, resources could potentially be redirected towards socialising some of the less acceptable interventions rather than addressing community hesitancy that may in fact not be there. That is, managers may be directing more resources than what is required to engagement and communication for some interventions that restrict or change human behaviour, or prioritising interventions over others, because they think that the public will not find them acceptable.

4.3. Study limitations

Before presenting recommendations based on our research, it is essential to recognise the limitations of the methodology employed. Small sample size is often a concern; however, due to the small number of 'technical experts' in the management of flatback turtles, particularly in Western Australia, the sample size could not be increased. Nevertheless, previous studies investigating expert opinion through quantitative survey methods have had similar numbers of participants and yielded robust data (e.g. Hobday et al. 2015a, Wilcox et al. 2018). We also acknowledge that the experts identified here come from a Western scientific background, and therefore only represent one type of knowledge and 'expert'. While every effort was made to obtain a breadth of expertise and demographics of the expert respondents, due to time and resource constraints, sufficiently engaging with experts from other knowledge systems (e.g. traditional knowledge holders) was not possible. Finally, it is important to note that administering surveys with communities also has unique limitations and challenges that should be acknowledged (Cvitanovic et al. 2022). For example, undertaking in-person community surveys during the COVID-19 pandemic may have impacted the number of participants choosing to engage with the research team. Additionally, we point to voluntary response bias, whereby participants who volunteer may be more likely to have a stronger opinion on a topic at the exclusion of those with neutral opinions. While our methods were chosen to capture responses from diverse community members, it is not possible to ensure that all relevant perceptions and opinions are captured.

4.4. Recommendations

As the assumption that experts can predict community acceptance of management interventions that reduce threats was not robustly supported, several recommendations arise from this study that can help proponents of conservation interventions to increase the chance of successful outcomes.

(1) Decision-making agencies should engage meaningfully with residents and stakeholders to understand their acceptance of conservation interventions, and the values that inform their acceptance. This can then be used to inform more effective and efficient engagement and communication strategies that account for the plurality of stakeholders and their values (Ison et al. 2021). Understanding and considering local values and social acceptability of interventions prior to implementation is particularly important when interventions may be controversial (e.g. infrastructure construction that impedes use or view of natural areas) or more technical (e.g. genetic modification), as strongly held value-based beliefs, gaps in literacy or lack of technical understanding of the intervention options may influence an individual's acceptance of the interventions (Kelly et al. 2022). This may, in turn, lead to local interference with the intervention and associated infrastructure (e.g. non-compliance). To overcome non-compliance, tailored communication and engagement strategies can be used to improve knowledge, support, and social acceptability and therefore the success of the implementation.

(2) Social acceptability assessments should be performed over regular temporal periods (e.g. annually or when new options are proposed), as views may not be static, and neither are communities. While undertaking community surveys is often a time-consuming and costly process, it is an important step in designing and implementing management decisions that will be accepted by communities and thus ultimately lead to successful conservation outcomes. Given their local contextual knowledge, community groups could be engaged to assist decision-making agencies by collecting the information needed to guide future intervention options.

(3) Engagement approaches need to be able to reach all segments of a community. For example, decision-making agencies should utilise a tailored survey approach and tool for Indigenous knowledge holders to ensure they are not accidentally excluded from surveys. Indigenous people may have other values that are associated with turtles that may not be adequately reflected in a simple 'acceptability survey', and as such, other more participatory research methods should be considered. For example, decision-making agencies could consider undertaking knowledge co-production processes alongside Indigenous knowledge holders in regions with populations of flatback turtles.

(4) Decision-making agencies should consider developing in-house expertise to assess social acceptability (i.e. embedded social scientists within the agency). In doing so, it will ensure there are the capabilities and capacity to undertake local and context-specific social acceptability research, and that this knowledge is effectively brokered with the community through tailored engagement and communication.

Acknowledgements. We appreciate the engagement by local community groups in Port Hedland (Care for Hedland) and Broome (Cable Beach Turtle Monitoring Club), and the Department of Biodiversity, Conservation and Attractions staff for assisting with the distribution of the survey. We thank the technical experts and residents of Broome and Port Hedland for their participation. This research was undertaken as part of the North West Shelf Flatback Turtle Conservation Program (NWSFTCP), and specifically, the Flatback Futures Program (https://research.csiro.au/teps/current-activities/flatbackfutures/), and ethics permit 067/21.

LITERATURE CITED

Ajzen I, Fishbein M (1980) Understanding attitudes and predicting social behavior. Prentice-Hall, Englewood Cliffs, NJ

Australian Bureau of Statistics (2021) Employment and income [Census TableBuilder]. https://tablebuilder.abs.gov.au/

Ban NC, Klein CJ (2009) Spatial socioeconomic data as a cost in systematic marine conservation planning. Conserv Lett 2:206–215

Beaugrand G, Edwards M, Legendre L (2010) Marine biodiversity, ecosystem functioning, and carbon cycles. Proc Natl Acad Sci USA 107:10120–10124

Bennett NJ (2016) Using perceptions as evidence to improve conservation and environmental management. Conserv Biol 30:582–592

Bennett NJ, Roth R, Klain SC, Chan K and others (2017) Conservation social science: understanding and integrating human dimensions to improve conservation. Biol Conserv 205:93–108

Brunson MW, Shindler BA (2004) Geographic variation in social acceptability of wildland fuels management in the western United States. Soc Nat Res 17:661–678

Bryman A (2016) Social research methods (5th edn.). Oxford University Press, New York, NY

Care for Hedland (2022) Turtle monitoring. https://careforhedland.org.au/turtle-monitoring/ (accessed 25 January 2023)

Catalogue of Bias Collaboration, Banerjee A, Nunan D (eds) (2019) Availability bias. In: Catalogue of Bias. www.catalogofbias.org/availability-bias

Cornell S, Berkhout F, Tuinstra W, Tàbara JD and others (2013) Opening up knowledge systems for better re-

sponses to global environmental change. Environ Sci Policy 28:60–70
Creighton C, Hobday AJ, Lockwood M, Pecl GT (2016) Adapting management of marine environments to a changing climate: a checklist to guide reform and assess progress. Ecosystems 19:187–219
Cvitanovic C, van Putten E, Hobday A, Mackay M and others (2018) Building trust among marine protected area managers and community members through scientific research: insights from the Ningaloo Marine Park, Australia. Mar Policy 93:195–206
Cvitanovic C, van Putten EI, Tuohy P, Annand-Jones R (2022) Normalizing failure: when things go wrong in participatory marine social science fieldwork. ICES J Mar Sci 79:2184–2195
Doney SC, Ruckelshaus M, Duffy JE, Barry JP and others (2012) Climate change impacts on marine ecosystems. Annu Rev Mar Sci 4:11–37
Drijfhout M, Kendal D, Green P (2022) Mind the gap: comparing expert and public opinions on managing overabundant koalas. J Environ Manage 308:114621
FitzSimmons NN, Pittard SD, McIntyre N, Jensen MP and others (2020) Phylogeography, genetic stocks, and conservation implications for an Australian endemic marine turtle. Aquat Conserv 30:440–460
Goodman LA (1961) Snowball sampling. Ann Math Stat 32: 148–170
Halpern BS, Walbridge S, Selkoe KA, Kappel CV and others (2008) A global map of human impact on marine ecosystems. Science 319:948–952
Hobday AJ, Chambers LE, Arnould JPY (2015a) Prioritizing climate change adaptation options for iconic marine species. Biodivers Conserv 24:3449–3468
Hobday AJ, Chambers LE, Arnould JPY (2015b) Methods to prioritise adaptation options for iconic seabirds and marine mammals impacted by climate change. In: Palutikof JP, Boulter SL, Barnett J, Rissik D (eds) Applied studies in climate adaptation. Wiley, Chichester, p 77–94
Hobday A, Pecl G, Fulton B, Pethybridge H, Bulman C, Villanueva C (2018) Climate change impacts, vulnerabilities and adaptations: Australian marine fisheries. In: Barange M, Bahri T, Beveridge M, Cochrane K, Funge-Smith S, Poulain F (eds) Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper 627. FAO, Rome, p 347–362
Iacarella JC, Clyde G, Bergseth BJ, Ban NC (2021) A synthesis of the prevalence and drivers of non-compliance in marine protected areas. Biol Conserv 255:108992
IPCC (2014) Summary for policymakers. In: Field CB, Barros VR, Dokken DJ, Mach KJ and others (eds) Climate change 2014: impacts, adaptations, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, p 76–77
Ison S, Pecl G, Hobday AJ, Cvitanovic C, Van Putten I (2021) Stakeholder influence and relationships inform engagement strategies in marine conservation. Ecosyst People 17:320–341
Kelly R, Pecl GT, Fleming A (2017) Social licence in the marine sector: a review of understanding and application. Mar Policy 81:21–28
Kelly R, Evans K, Alexander K, Bettiol S and others (2022) Connecting to the oceans: supporting ocean literacy and public engagement. Rev Fish Biol Fish 32:123–143
Madin EM, Ban NC, Doubleday ZA, Holmes TH, Pecl GT, Smith F (2012) Socio-economic and management implications of range-shifting species in marine systems. Glob Environ Change 22:137–146
Nash KL, van Putten I, Alexander KA, Bettiol S and others (2022) Oceans and society: feedbacks between ocean and human health. Rev Fish Biol Fish 32:161–187
Park SE, Marshall NA, Jakku E, Dowd AM, Howden SM, Mendham E, Fleming A (2012) Informing adaptation responses to climate change through theories of transformation. Glob Environ Change 22:115–126
Pecl GT, Araújo MB, Bell JD, Blanchard J and others (2017) Biodiversity redistribution under climate change: impacts on ecosystems and human well-being. Science 355: eaai9214
Pecl GT, Ogier E, Jennings S, van Putten I and others (2019) Autonomous adaptation to climate-driven change in marine biodiversity in a global marine hotspot. Ambio 48:1498–1515
Pendoley KL, Bell CD, McCracken R, Ball KR and others (2014) Reproductive biology of the flatback turtle *Natator depressus* in Western Australia. Endang Species Res 23:115–123
Red List Standards & Petitions Subcommittee (1996) *Natator depressus* (errata version published in 2022). The IUCN Red List of Threatened Species: e.T14363A210612474
Ressurreição A, Simas A, Santos RS, Porteiro F (2012) Resident and expert opinions on marine related issues: implications for the ecosystem approach. Ocean Coast Manag 69:243–254
Stankey GH, Shindler B (2006) Formation of social acceptability judgments and their implications for management of rare and little-known species. Conserv Biol 20:28–37
Tuohy P, Cvitanovic C, Shellock RJ (2022) Understanding visitor awareness and knowledge of marine parks: insights from the Ningaloo Coast, Australia. Ocean Coast Manage 227:106282
van Putten IE, Cvitanovic C, Tuohy P, Annand-Jones R and others (2023) A focus on flatback turtles: the social acceptability of conservation interventions in two Australian case studies. Endang Species Res 52:189–201
Voyer M, Gollan N, Barclay K, Gladstone W (2015) 'It's part of me'; understanding the values, images and principles of coastal users and their influence on the social acceptability of MPAs. Mar Policy 52:93–102
Whittock PA, Pendoley KL, Hamann M (2014) Inter-nesting distribution of flatback turtles *Natator depressus* and industrial development in Western Australia. Endang Spec Res 26:25–38
Wilcox C, Hobday AJ, Chambers LE (2018) Expert elicitation of anticipated climate impacts on iconic Australian marine species. Ecol Indic 95:637–644
Young JC, Jordan A, Searle KR, Butler A, Chapman DS, Simmons P, Watt AD (2013) Does stakeholder involvement really benefit biodiversity conservation? Biol Conserv 158: 359–370

Editorial responsibility: Mark Hamann, Townsville, Queensland, Australia
Reviewed by: N. J. Pilcher, E. McKinley, M. Ware

Submitted: February 11, 2023
Accepted: October 5, 2023
Proofs received from author(s): December 21, 2023