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RESEARCH ARTICLE

A two-phase approach to elicit and measure beliefs on management strategies: Fishers supportive and aware of trade-offs associated with stock enhancement

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Abstract Understanding fisher beliefs and attitudes towards specific management strategies can help inform and improve fisheries management, and thus stock sustainability. Previous studies highlight a lack of fisher awareness regarding environmental issues influencing the systems they utilise and the negative impacts of specific strategies, such as stock enhancement. Our study used a two-phase approach to first elicit and then measure the strength of common fishers' beliefs and associated attitudes regarding stock enhancement. Specifically, this research focused on recreational fishers of an estuarine crab fishery (*Portunus armatus*) in south-western Australia. The results demonstrate that recreational fishers believe stock enhancement could have strong positive outcomes, but also recognise that this management strategy could lead to some negative outcomes, though the latter are perceived as less likely to happen. This contrasts with previous research on fisheries stocking and demonstrates the value of using the two-phase approach to clarify fishers' perceptions of particular management approaches. To reduce fisher dissatisfaction with management actions, careful communication on the benefits and costs of stock enhancement is recommended. Our study highlights the significance of integrating social sciences into fisheries research, and the need to better understand fishing community beliefs to ensure effective management of the fishery.

Keywords Crustaceans · *Portunus armatus* · Recreational fisheries · Restocking · Social dimensions · South-western Australia

INTRODUCTION

Understanding and incorporating social dimensions into fisheries management is now considered vital, as it can help mitigate conflict and foster fisher and other stakeholder support for management regulations (Mikalsen and Jentoft 2001; Fulton et al. 2011). Recreational fishing is a significant activity worldwide, in terms of both the numbers of fishers, their fishing effort and the size of their catch (Arlinghaus 2006; Cooke and Cowx 2006; Taylor et al. 2017). Its widespread popularity, and often lack of restrictive regulations and periodic monitoring, results in significant impacts on fish stocks globally, causing changes in abundance, age and size structures (Arlinghaus et al. 2016; Hyder et al. 2017; Arlinghaus et al. 2019). Various management approaches may be used to mitigate or minimise the impacts of fishing on stocks, including aquaculture-based enhancement (i.e. stock enhancement, restocking and sea ranching). While such enhancements are generally supported by recreational fishers, they involve trade-offs among ecological, social and economic objectives that may not align with the beliefs, attitudes and associated expectations of recreational fishers (Garlock and Lorenzen 2017). Understanding the beliefs and attitudes of resource users regarding particular management approaches can help inform and develop positive relationships between users and managers that contribute to more appropriate and accepted management approaches (McPhee et al. 2002; Sténs et al. 2016). This paper presents research that elicited, then measured recreational fishers' common beliefs and attitudes regarding the potential stock enhancement of a popular estuarine recreational crab fishery. It provides the basis for developing a better understanding of how fishers view stock enhancement as a potential management approach.

Traditional fisheries management commonly impose input (e.g. effort and permissible fishing methods), output (e.g. landings and size limits) and access (e.g. seasonal and area closures) controls on fisheries to mitigate pressures, such as growth in recreational fishing effort, that might lead to a decline in stocks (Brummett et al. 2013; Lorenzen 2014; Gallagher et al. 2017). However, these measures can cause hardship for fishers through, for example, reducing the days or areas available for fishing (Mascia et al. 2010). Stock enhancement is widely used in freshwater, estuarine and marine environments (Bell et al. 2008; Broadley et al. 2017; Taylor et al. 2017) and is seen as a means for sustaining both fishing effort and stocks in the face of increasing pressures. Thus, it is commonly used in fisheries and it is considered particularly popular among recreational fishers (Garlock and Lorenzen 2017). Therefore, its use as a management intervention is projected to grow (Cooke and Cowx 2006; Von Lindern and Mosler 2014).

Stock enhancement can involve trade-offs whereby negative impacts may counter catch-related benefits for recreational fishers (Camp et al. 2017). For example, negative outcomes of stock enhancement can include (i) biological differences between wild and hatchery-reared populations, which result in cultured individuals being less fit for natural environments due to a difference in their genetic structure (Lorenzen 2008; Lorenzen et al. 2012); (ii) reduction in the abundance of fish with wild characteristics due to stocked fish interacting with wild fish, through reproduction, predation or competition (Bell et al. 2008; Ingram et al. 2011; Camp et al. 2017); (iii) increased numbers of smaller individuals and slower growth to maturity, due to density-dependent effects on growth (Satake and Araki 2012; Anderson and Cason 2015) and (iv) increase in recreational or commercial fishing effort as a response to a boost of the stocks in the exploited system (Hilborn 1998; Camp et al. 2017). These negative impacts represent a trade-off between maintaining recreational fishing effort and the ecological viability of the fishery (Van Poorten et al. 2011; Von Lindern and Mosler 2014). Several studies have found that, in general, recreational fishers have unrealistic beliefs about stock enhancement outcomes and are not aware of the potential disadvantages of stock enhancement (Van Poorten et al. 2011; Garlock and Lorenzen 2017). This usually leads to the conclusion that recreational fishers require more education to ensure that their beliefs are aligned with those of fishery managers and the available scientific knowledge, and thus avoid conflict, loss of support and less compliance with management (Arlinghaus et al. 2016; Beckley and Prior 2007). On the other hand, misconceptions from experts regarding fisher beliefs (e.g. lack of awareness on negative impacts) about the fishery may result in inappropriate management responses that may also create tensions between fishers and managers (Connelly and Knuth 2002).

In Australia, the portunid crab *Portunus armatus* holds great social and economic importance as a recreational and small-scale commercial fishery (e.g. Sumpton et al. 2003; Ryan et al. 2015). Recreational crab fishers may be boat-based or shore-based (jetties, snorkelling/diving or wading), using a variety of simple, cheap equipment such as drop nets and scoop nets (Johnston et al. 2015). In Western Australia, *P. armatus* is the most popular target species among recreational fishers (Sumner and Williamson 1999; Malseed and Sumner 2001), with an estimated 9 00 000 crabs caught by boat-based recreational fishers over the 12-month period from May 2013 to April 2014 (Ryan et al. 2015). Crabbing effort in the Peel-Harvey Estuary alone was estimated to be around 3200 fisher days in winter, compared to over 80 900 fisher days in summer (Malseed and Sumner 2001). The recreational crab fishery is considered a food-motivated fishery, with the main motivation of recreational crab fishers being to "Catch crabs to eat" (Poulton 2018). The increased popularity of crab fishing and the growing population of Western Australia, coupled with the closure of a nearby marine embayment (Cockburn Sound) to crab fishing, has resulted in *P. armatus* stocks in south-western Australian estuaries being subjected to increasing pressures, such as environmental degradation due to urbanisation and increasing fishing pressure (Johnson et al. 2011; Tweedley et al. 2016).

In light of the pressures on estuarine stocks, Johnson et al. (2011) suggested that stock enhancement be considered as a way of increasing the abundance of *P. armatus*. A small-scale trial was conducted in the austral summer of 2016/17 (December to February) resulting in the release of 3700 juvenile crabs into the Peel-Harvey Estuary in south-western Australia (Jenkins et al. 2017). While the biological and ecological aspects of *Portunus* spp. aquaculture and stock enhancement are relatively well studied (e.g. Marshall et al. 2005; Paterson et al. 2007), the social dimensions, including fisher beliefs and attitudes, are not well understood beyond a general acknowledgement that crabbing is popular, and that declines in stocks and catch would generate public concern. Thus, the recreational fishery for *P. armatus* presented an ideal opportunity for eliciting and measuring the beliefs and attitudes of recreational fishers regarding stock enhancement and its advantages and disadvantages as a management approach.

Our study applied a two-phase approach to first elicit and then measure the beliefs and associated attitudes of recreational crab fishers towards the management of the *P. armatus* fishery in the Swan-Canning, Peel-Harvey and Leschenault estuaries in south-western Australia (Fig. 1). Our study draws on belief elicitation and measurement techniques associated with the application of the theory of

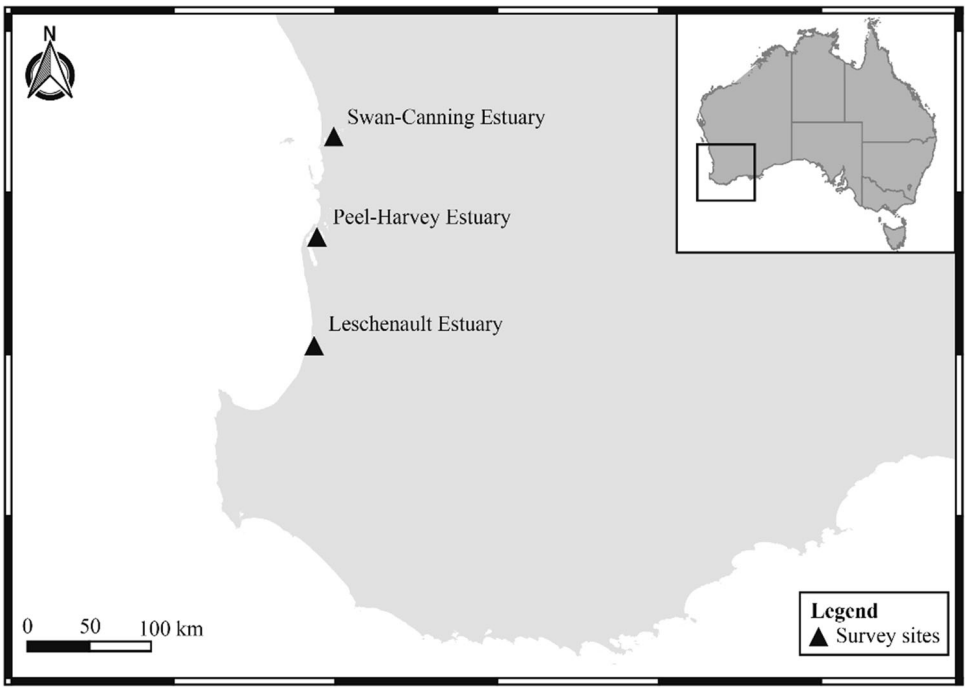

Fig. 1 Location of the three estuaries in south-western Australia where interviews with recreational fishers were conducted. (i) Swan-Canning Estuary (area = 55 km^2, maximum depth = 21 m and average depth = < 5 m) (ii); Peel-Harvey Estuary (area = 131 km^2, maximum depth = 2.5 m and average depth = 0.5); (iii) Leschenault Estuary (area = 25 km^2, maximum depth = 2 m, average depth < 1 m). Surveys to elicit and then measure the beliefs and attitudes of recreational fishers towards management of the *Portunus armatus* fishery were conducted during the Austral summer (November 2017 to March 2018)

planned behaviour (TPB; Ajzen 1991). The TPB describes the relationship between human beliefs, attitudes and behaviour within a structured framework. According to the TPB, three categories of belief underpin attitudes and behaviour: behavioural beliefs about the positive or negative outcomes of a behaviour and the evaluations of those outcomes; normative beliefs about influential people who may approve or disapprove of a behaviour; and control beliefs about factors that may help or hinder attempts to perform a behaviour (Hughes et al. 2012). The aim of the current study is to apply a method which first identifies fisher beliefs and attitudes about the likely outcomes of stock enhancement as a management approach then relates these to the level of support for stock enhancement. This study appears to be the first application of such an approach to a fishery and focusses on the *P. armatus* recreational fishery, in south-western Australia.

MATERIALS AND METHODS

Data collection was carried out in two phases: Phase 1 focused on belief elicitation and Phase 2 on belief measurement, adapting techniques used in previous TPB-based belief elicitation and measurement research (Brown et al. 2010; Hughes et al. 2009, 2012). The first phase identified recreational fisher beliefs about the likely outcomes of *P. armatus* stock enhancement (Phase 1), with these responses then used to develop the belief measurement survey (Phase 2).

Phase 1: belief elicitation

This phase followed the belief elicitation procedures applied by Hughes et al. (2009, 2012). Face-to-face interviews were carried out at a range of locations on three estuaries used by recreational crab fishers in south-western Australia. These were (i) the Peel-Harvey Estuary, due to the present and historical importance of crab fishing in this system (Mandurah; population ~ 80 813), (ii) the Swan-Canning Estuary, being the main urban and most highly populated system in the region (Greater Perth; population ~ 2 039 193) and (iii) the Leschenault Estuary, a more rural system (Bunbury; population ~ 32 244), all of which are located within ~ 180 km of Perth (Fig. 1). A total of 18 sites (i.e. jetties, boat ramps and shore line areas frequented by crab fishers) were sampled, providing a representative cross section of *P. armatus* recreational fishing across south-western Australia. Note that sampling was not conducted south of the Leschenault Estuary, as this species is less abundant in these waters (DPIRD 2018), which may influence the accuracy of fishers' beliefs.

The survey involved face-to-face interviews, using a structured, open-question format carried out by experienced researchers. The survey was designed to gather, in the fishers' words, the beliefs associated with stock enhancement of the *P. armatus* fishery. Belief elicitation questions were paired and focussed on the positive or negative outcomes a fisher might expect from crab stock enhancement, drawing on the behavioural belief component of the TPB procedure (Hughes et al. 2012). Consenting recreational crab fishers were asked a series of open-ended questions (see Table 1). The interview was pretested with a small sample of recreational crab fishers, to ensure each question was appropriately worded and clearly understood.

The Phase 1 survey was conducted during times when people were most likely to be fishing for crabs (i.e. during the morning or afternoon) on weekends and weekdays during the peak of the *P. armatus* fishing season (austral summer, i.e. November 2017 to March 2018; Malseed and Sumner 2001). All recreational crab fishers at each sample site were approached with a request to participate in the interview. The responses were written down by the interviewers using the respondents' words. A theoretical saturation approach was adopted for belief elicitation. Accordingly, interviews with recreational crab fishers were carried out across the three estuaries until no new response types were recorded from each estuary (Hughes et al. 2009, 2012). Theoretical saturation was mathematically confirmed by adapting species accumulation techniques (Ugland et al. 2003), to develop response accumulation curves (Vanwindekens et al. 2013). Additional interviews were conducted once saturation was achieved to ensure that no salient beliefs were overlooked.

Responses were transcribed to a spreadsheet and reviewed to develop categories of response representing salient beliefs. Three researchers independently conducted content analysis to group responses with similar meaning and then identify salient beliefs based on their frequency of occurrence. The salient beliefs identified in Phase 1 were then incorporated into Phase 2.

Table 1 Questions asked to recreational fishers' about their awareness, beliefs and attitude to stock enhancement in the belief elicitation survey

Stock enhancement awareness
1. Do you know what stock enhancement is? [explain]
2. Are you aware of any past fishery stock enhancement events?
Stock enhancement beliefs
3. What do you think are the advantages or good things that could occur if stock enhancement is used to manage the crab fishery in this estuary?
4. What do you think are the disadvantages or bad things that could occur if stock enhancement is used to manage the crab fishery in this estuary?
Demographics
Age, gender, place of residence

Phase 2: belief measurement

The second phase involved an online, fixed-item questionnaire distributed to the Western Australian recreational crab fishing community. The survey included a range of questions about *P. armatus* fishing and management. This paper specifically focuses on the stock enhancement belief strength (i.e. likely-unlikely) and evaluation (i.e. good-bad) measurement components of this online survey.

Following belief measurement procedures (Ajzen 1991), two questions were asked for each of the salient beliefs, one rating how likely or unlikely the outcome was (strength) and one rating how good or bad the outcome was (evaluation). The dual measures were multiplied together to form a cross-product that represented the belief-based attitude. Based on the coding scheme recommended by Ham et al. (2008), belief strength was measured on a 7-point scale from 0 ('very unlikely') to + 6 ('very likely'). The accompanying belief evaluation was measured on a scale from − 3 ('very bad') to + 3 ('very good'). The range for resulting cross-products for each belief (i.e. the belief-based attitude score) was − 18 (very likely/very bad) to + 18 (very likely/very good). A separate overall attitude question asked respondents to rate whether stock enhancement was a very bad or a very good thing to do on a 7-point scale (i.e. − 3 to + 3). The online survey also included a range of questions focused on when, how often, where and how fishers caught *P. armatus*, what they do with their catch, evaluations of a range of current and potential crab fishery management approaches and basic demographics of the respondent.

The questionnaire was developed and distributed using the online survey tool Surveygizmo (Widgix 2005). The online questionnaire was pretested with a small sample of fishers ($n = 5$) before being released to the public on 21 December 2017 and was closed on 21 July 2018. Participation in the survey was promoted via a press-release circulated by local print and broadcast media and flyers were posted at sample sites and convenience stores, bait/tackle stores and cafes located close to the estuaries. The survey was also promoted through posts on social media, targeting recreational crab fishers and via dedicated fishing forums. All responses to the online survey were analysed using R Studio (Version 3.3.1) and SPSS (Version 24). The non-parametric Kruskal–Wallis and Wilcoxon tests were used to compare the belief and attitude rating scores, as well as comparisons of belief and attitude ratings among groups of

respondents (unsupportive, neutral and supportive of stock enhancement).

RESULTS

The respondents of the Phase 1 (face-to-face interviews) were mostly male (86.7%) and residents of Western Australia (98.9%). These respondents ranged from 18 years old to > 65, with a modal age group of 35 to 44 years (24.5%). Similarly, Phase 2 (online survey) respondents were predominantly males (83.9%) that resided in Western Australia (99.4%), spread uniformly across the ages from 18 to > 65 years old, with the highest proportion of respondents in the 35–44-year-old category (27.1%). These results show that the face-to-face survey provides a similar representation of recreational crab fishers to that of the online survey.

Phase 1: belief elicitation

Across the three estuaries, researchers approached 109 recreational fishers, of whom 94 agreed to participate in an interview. This response rate (86.2%) was higher than the mean response rates reported by previous interview type studies (e.g. Aansel et al. 2010). Theoretical saturation of responses was achieved for each estuary prior to 25 interviews being conducted, with corresponding response accumulation curves all reaching an asymptote (Fig. 2).

Salient beliefs associated with positive outcomes of crab stock enhancement were more frequently stated (91.5% of respondents) than those associated with negative outcomes (39.4%). The two most frequently stated beliefs were that stock enhancement would (i) increase the number of crabs in the estuary and (ii) result in more crabs to catch, that is, more crabs of minimum legal size in the catch (Table 2). Interestingly, while many respondents indicated there were no disadvantages associated with stock enhancement,

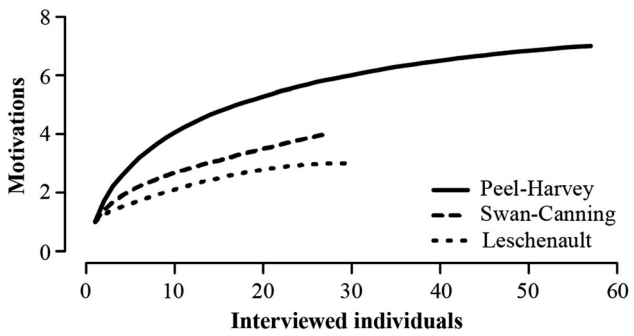

Fig. 2 Response accumulation curves, generated from 1000 permutations, for the number of motivations for *Portunus armatus* fishing in the Peel-Harvey, Swan-Canning and Leschenault estuaries with increasing numbers of interviews with recreational fishers

Table 2 Salient (i.e. positive and negative) beliefs recreational fishers associated with the stock enhancement *Portunus armatus* in the estuary where they fished, from interviews with fishers (Phase 1, $n = 94$). Note, respondents may provide more than one answer to each question

Questions and answers	Frequency (n)	Percentage of respondents (%)
Q. What are the advantages or good things that could occur if stock enhancement is used to manage the crab fishery in this estuary?		
Increase the number of crabs	41	43.6
More crabs to catch	32	34.0
I don't know/unclear	13	13.8
None	12	12.8
Good for environment and other species	8	8.5
Good for tourism/economy	5	5.3
More oversized crabs	4	4.3
NA	1	1.1
Q. What are the disadvantages or bad things that could occur if stock enhancement is used to manage the crab fishery in this estuary?		
None	47	50.0
Impact on environment and other species	13	13.8
Increase the fishing pressure on the crabs	9	9.6
Unnecessary—there are already heaps of crabs	6	6.4
Cost	5	5.3
I don't know/unclear	5	5.3
NA	4	4.3
Affect crabs' genetics and produce diseases	2	2.1
Crabs could leave the estuary	2	2.1

almost 40% of respondents reported that enhancement of *P. armatus* could result in negative outcomes such as (i) environmental impacts on the estuary, other species and the crabs as well as (ii) increased fishing pressure. Thus, the elicitation phase (Phase 1) demonstrated that two out of five recreational crab fishers were aware of the potential negative outcomes of stock enhancement. The most frequent beliefs associated with potential positive and negative outcomes of stock enhancement were incorporated into the online survey to measure the belief strength and evaluation.

Phase 2: belief measurement

A total of 575 crab fishers participated in the online survey, with 357 responding to all questions (62% completion rate). The beliefs associated with the advantages of stock enhancement of crabs (i.e. "Increase number of crabs" and

"More crabs to catch") were considered to be both likely and good outcomes, resulting in a high belief-based attitude score (Table 3). The beliefs associated with disadvantages of stock enhancement, i.e. (a) "Increase the fishing pressure" and (b) "Impact on environment and other species", were rated significantly less likely than the advantages (Wilcoxon test, W(a) = 57464; W(b) = 58406, $p < 0.001$), and rated as a bad outcome (i.e. scale of − 3 to + 3). The belief-based attitude scores associated with the disadvantages of stock enhancement were therefore low and negative. The mean overall attitude rating for crab stock enhancement was + 1.75 (scale from − 3 to + 3; $n = 308$; Fig. 3) indicating general support for the management practice. This was also reflected in the frequencies of response, where 86.4% of responses were positive (supportive), 4.2% were neutral and 9.4% were negative (not supportive) towards stock enhancement of crab (Fig. 3).

The mean belief strength and evaluation ratings towards crab stock enhancement differed significantly among the three overall attitude respondent groups (i.e. supportive, neutral, not supportive; Kruskal–Wallis $\chi^2_2 = 86.177$, $p < 0.001$; Table 4). While each group indicated a positive belief-based attitude towards the advantages of stock enhancement neutral and unsupportive fishers rated these outcomes as significantly less likely and less good compared to supportive fishers (Table 4). In terms of the disadvantages of stock enhancement, all three groups rated these outcomes as equally bad; however, the unsupportive and neutral groups rated them as being significantly more likely than the supportive group. Overall, recreational fishers supporting stock enhancement believe that the disadvantages of enhancing crabs are less likely to occur, while the advantages are more likely and good, compared to the response of fishers who were unsupportive or neutral about this enhancement.

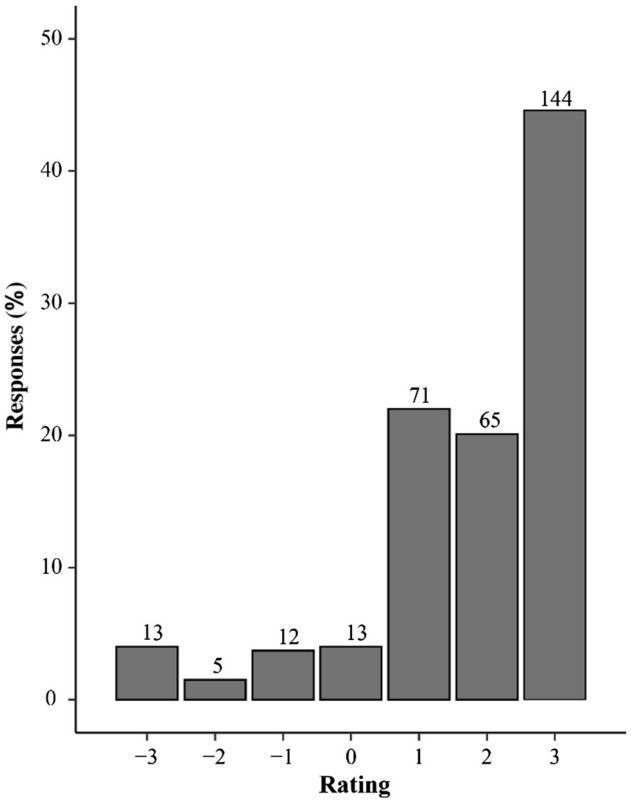

Fig. 3 Responses to question "Overall, I think using stock enhancement as a management option for blue swimmer crabs in the Estuary where I fish most is:" indicating the overall attitude of fishers towards stock enhancement as a management approach for the *Portunus armatus* fishery. The number of respondents who chose each rating is provided above each bar; $n = 323$

Table 3 Summary of mean belief strength; valuation ratings and cross-products associated with stock enhancement of *Portunus armatus* from the online survey (phase 2) of recreational fishers

Beliefs	Strength 0 to 6*		Evaluation − 3 to 3**		Cross-product − 18 to 18***	
	N	Mean	*N*	Mean	*N*	Mean
Increase number of crabs	337	4.78	351	2.14	319	11.5
More crabs to catch	331	4.82	352	2.17	317	11.54
Increase the fishing pressure on crabs	283	3.05	318	− 1.5	265	− 4.09
Impact on the environment and other species	284	2.87	278	− 1.3	237	− 2.47

*; ** and *** refer to "unlikely to likely"; "bad to good" and "belief-based attitude" respectively

DISCUSSION

By implementing an open-ended interview (Phase 1) followed by an online survey (Phase 2), this paper provided added insights into the beliefs and attitudes of recreational crab fishers towards using stock enhancement as a management approach. It provides information on the social dimensions of a significant recreational fishing activity in south-western Australia, including fishers' perceptions regarding management approaches (Hunt et al. 2013). Understanding fisher perceptions can provide insights into how to build support and mitigate conflict associated with fisheries management (Mikalsen and Jentoft 2001; Fulton et al. 2011). In this regard, Ham et al. (2008), Hughes et al. (2009) noted that expert assumptions about public perceptions of management might not reflect the full range of perceptions that exists within a target group. Published research on fisher perceptions is based mainly on asking

Table 4 Mean values from the online survey responses regarding the mean belief strength, evaluation ratings and cross-products associated with stock enhancement *Portunus armatus*, for the three fishing groups studied: Supportive (S); Neutral (N) and Unsupportive (US) to stock enhancement. Note that "*n*" = number of respondents for each measure

Beliefs	Strength 0–6				Evaluation − 3 to + 3 (bad–good)				Cross-product − 18 to + 18 (belief-based attitude)			
	S	*N*	US	*n*	*S*	*N*	US	*n*	*S*	*N*	US	*n*
Increase number of crabs	5.13	3.92	2.57	295	2.38	1.50	− 0.04	352	12.62	6.60	2.04	287
More crabs to catch	5.14	4.36	2.25	331	2.35	1.42	0.72	353	12.63	5.70	2.95	281
Increase the fishing pressure on crabs	2.88	4.08	4.15	283	− 1.44	− 1.23	− 2.13	319	− 3.26	− 5.00	− 9.52	235
Impact on the environment and other species	2.87	3.25	4.03	284	− 1.12	− 1.75	− 2.28	278	− 1.21	− 5.91	− 9.31	218

fishers to rate predetermined categories provided by expert researchers (e.g. Anderson et al. 2007; Van Poorten et al. 2011; Garlock and Lorenzen 2017). The findings of the current study indicate that fishers' support for crab stock enhancement appears to depend on how positively they perceive the elicited advantages of stock enhancement and the perceived likeliness of elicited positive and negative outcomes.

Owing to the pressures on the blue swimmer crab stocks, stock enhancement has been considered as a way of increasing the abundance of *P. armatus* (Johnson et al. 2011). As a result of this interest in enhancement, a pilot release of 3700 juvenile crabs was made in the Peel-Harvey Estuary to explore the feasibility and logistics of enhancement (Jenkins et al. 2017). While the biological and ecological aspects of *Portunus* spp. aquaculture and stock enhancement are relatively well studied (e.g. Marshall et al. 2005; Paterson et al. 2007), the human dimensions, including fisher beliefs and attitudes, are not well understood. The belief elicitation process was key to identifying fishers' beliefs regarding the potential outcomes of using stock enhancement to manage the *P. armatus* fishery. This belief elicitation technique revealed that most crab fishers (96.8%) identified catch-related positive outcomes (advantages) of stock enhancement, but fewer (39.4%) identified potential negative outcomes of stock enhancement. These findings on a short-lived invertebrate parallel with those for longer-lived fin-fish (red drum, *Sciaenops ocellatus*) by Garlock and Lorenzen (2017), and generic modelled results for fish by Van Poorten et al. (2011), who both found strong support for stock enhancement as a fisheries management intervention, but with potentially unrealistic beliefs about the potential benefits and negative impacts of stock enhancement. In particular, the common and strongly held belief in the current study that stock enhancement will lead to greater catches of crabs (i.e. more crabs of at least minimum legal size) may be an unrealistic belief. While stock enhancement may increase overall numbers, this is typically associated with sizes of the target species becoming smaller, due to density-dependent effects on growth (Hilborn 1998; Camp et al. 2017). Thus, stock enhancement of *P. armatus* is not guaranteed to increase the number of crabs caught because many will be below the minimum legal-size limit. The catch-related beliefs align with findings from previous studies on various fish species in the northern hemisphere (e.g. Anderson et al. 2007; Garlock and Lorenzen 2017), which noted that consumptive-oriented fishers tend to support stock enhancement as it is perceived to help them achieve their aims of catching many and large fish. It was also noted that these expectations might be unrealistic, requiring managers to carefully communicate the benefits and costs of stock enhancement to reduce fisher dissatisfaction (Garlock and Lorenzen 2017).

In contrast to previous work, the belief elicitation in our study also identified that a proportion of recreational fishers were aware of the potential negative outcomes (disadvantages) of stock enhancement in terms of increased fishing pressure and impacts on the "wild" crabs as well as other species. These beliefs aligned with those identified in the scientific literature, including increased fishing effort (Hilborn 1998; Camp et al. 2017), impacts on genetic diversity and fish abundance (Lorenzen et al. 2012), predation and competition between stocked and wild fish, and reducing the abundance of wild fish populations (Bell et al. 2008; Ingram et al. 2011; Taylor et al. 2017). While the elicitation revealed that a substantial minority of fishers (39.4%) were aware of these potential disadvantages, the belief measurement demonstrated that part of the population of recreational crab fishers rated them as bad, but unlikely outcomes of stock enhancement. These findings suggest that the popularity of stock enhancement among some recreational fishers has a more nuanced explanation than simply being unaware of the negative outcomes resulting from stock enhancement.

Perhaps it is not so much a general lack of awareness, but more an interplay between the perceived low likelihood of negative outcomes and the potentially unrealistic, perceived high likelihood of increased catch. Hence, when

provided with a list of potential outcomes, recreational crab fishers who support stock enhancement were likely to rate the perceived advantages as likely and positive, while downplaying the disadvantages that are still considered to be bad, but very unlikely. Meanwhile, those who are unsupportive consider the disadvantages to be more likely, while the catch-related advantages are seen as very likely but less positive. Although the beliefs regarding stock enhancement and increased catch reflect the findings from earlier studies, i.e. most recreational fishers support stock enhancement as a management intervention (Arlinghaus 2006), we demonstrate here that some fishers are also aware of the potential for negative outcomes from stock enhancement. Our findings, based on the two-phase approach, provide additional insight to the notion of incomplete understanding by fishers regarding the advantages and disadvantages of stock enhancement identified in previous studies (Hunt et al. 2013). This two-phase method could be applied to other fishery sectors (including commercial, artisanal and subsistence fisheries) to further improve understanding of fisher beliefs and attitudes towards management. Better understanding of fishers views on fisheries and their management can contribute to greater acceptance and compliance with management actions (McPhee et al. 2002; Sténs et al. 2016).

CONCLUSION

This study used established belief elicitation and measurement procedures to first identify, then measure beliefs regarding the outcomes of using stock enhancement as a management approach in fisheries. As with past studies of recreational fin-fish fisheries, crab fishers appeared to generally support stock enhancement as a tool to manage this fishery. Our elicitation method indicated that recreational crab fishers were aware of positive outcomes of stock enhancement, and in contrast to other studies, demonstrated that nearly 40% were also aware of potential negative outcomes. We found that a primary difference between fishers who strongly support stock enhancement and those who do not is the perceived likelihood of negative and positive outcomes. Thus, in managing fisher expectations on the outcomes of stock enhancement, while recreational fishers may be aware of positive and negative outcomes, communicating the relative likelihood of positive and negative outcomes may be warranted.

The use of a two-phase approach firstly allowed fishers to describe their beliefs, without experts (i.e. resource managers and scientists) imposing their assumptions to which fishers must respond. The belief elicitation approach afforded a reliable sample of the range of beliefs within the target fisher population. Secondly, measuring the strength and evaluation of elicited beliefs based on a wider sample of the fisher population provided more nuanced data in relation to fisher attitudes towards stock enhancement as a management approach. This two-phase method is a reliable means for identifying the complexities of fisher perceptions, whilst minimising influence of manager or researcher assumptions on what fishers think. While the focus of this study is on a recreational crab fishery, this method could be applied to different fisheries (i.e. different target species) as well as different fishery sectors, such as commercial or subsistence fisheries. Our findings and those from previous studies emphasise the importance of communication and engagement in fisheries management based on a firm understanding of the social dimensions of fishers (Mikalsen and Jentoft 2001; McPhee et al. 2002; Fulton et al. 2011; Sténs et al. 2016; Garlock and Lorenzen 2017). Adopting the two-phase method could help inform management more accurately of to whether fisher beliefs are aligned with those of fishery managers and the available scientific knowledge. This more nuanced information could contribute to more targeted communication and engagement, and thus avoid conflict and loss of support for management, and foster greater compliance with the regulations.

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