FINAL

Optimising compliance outcomes in recreational fisheries

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February 2023

FRDC Project No **2019/011**

ISBN 978-0-646-86519-5

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2019/011

2023

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Acknowledgments

I would like to sincerely thank the project team, Dr Timothy Green, Department of Primary Industries and Regional Development (DPIRD); Mr Sebastian Lambert, formerly Primary Industries and Regions South Australia (PIRSA); Mr Randell, PIRSA; and Dr William Dixon, Victorian Fisheries Authority (VFA) for their continued efforts and support throughout the project. Upheaval due to COVID-19 meant the project process and allocation of available time changed, including a change in team member. I also thank Mr Liam Quinn, University of Western Australia (UWA) PhD Candidate in Criminology, for his superb research assistance and data analysis throughout the project.

I also extend my gratitude to the project steering committee, namely Mr Leyland Campbell, RecFishWest; Dr James Tweedley, Murdoch University and PI of FRDC-funded project 2016-034; Mr John Looby, DPIRD (Retired); and Mr Anthony Chen, New South Wales Department of Primary Industries for their time and insights throughout the project.

Sincere thanks for the in-kind support from UWA, DPIRD, PIRSA, and VFA as well as the financial support from the FRDC on behalf of the Australian Government. Without the generous funding from the FRDC, this research would not have been possible.

Abbreviations

AFMF	Australian Fisheries Management Forum
DPIRD	Department of Primary Industries and Regional Development
FRDC	Fisheries Research and Development Corporation
PIRSA	Primary Industries and Regions South Australia
SA	South Australia
UWA	University of Western Australia
VFA	Victorian Fisheries Authority
WA	Western Australia

Executive Summary

Background

The purpose of this project was to better understand strategies to enhance compliant participation among recreational fishers, or 'cooperative compliance' without increasing the management risks[1] for the regulators, using the Peel-Harvey Blue Swimmer Crab fishery in Western Australia (WA) and the Blue Swimmer Crab fishery in South Australia (SA) as case studies. The results of this research can shape recreational fisheries education and enforcement strategies.

Objectives

This study had six objectives:

1. To characterise the quality and contents of compliance datasets held by WA and SA government agencies and specific to two recreational Blue Swimmer Crab fisheries, in order to evaluate their adequacy for social science research objectives such as longitudinal studies.
2. To analyse existing Blue Swimmer Crab compliance datasets for trends and insights and test those findings against reference groups.
3. To contrast recreational Blue Swimmer Crab fisher's attitudes towards compliance in WA and SA to their own, and the other jurisdictions' management frameworks.
4. Determine whether illegal catch can be estimated based on assessment of available data and analysis of drivers of noncompliance.
5. To conduct a proof of concept that scopes out the resources, expertise and design necessary to show changes in Blue Swimmer Crab fisher behaviour and attitudes and demonstrate any causality to education and enforcement strategies and their effect on 'cooperative compliance'.
6. To better understand how recreational Blue Swimmer Crab fishers in both jurisdictions obtain information and respond to education and enforcement strategies.

Method

The methodology was designed to gather information from the regulators that manage the fisheries and the relevant fishing cohort. Successful results were achieved in this project through five stages: 1) an environmental scan of the relevant existing compliance literature and review of the evolution of both jurisdiction's regulations for the fishery; 2) quantitative analyses of the datasets held by fisheries management regulators, WA Department of Primary Industries and Regional Development (DPIRD) and the Department of Primary Industries and Regions South Australia (PIRSA) to inform fishing effort, inspection, and offence data of noncompliers in both fisheries; 3) qualitative analyses of perceptions from online surveys conducted in WA and SA to fill in the gaps and expand insights about recreational fishing compliance; 4) based on those datasets, conduct a review to determine the effectiveness of existing education and enforcement strategies; and 5) undertake a summation of noncompliance datasets, compare behavioural trends and identify novel educational and enforcement strategies that could improve compliance.

[1] We define 'risks' as to broadly include risks to resources (financial, human) and environmental (stock sustainability).

Together, through these research pathways based on two case studies we provide an evidence-base to build a strategic approach to improve noncompliance management relevant to unlicensed recreational fishers.

Results

Against the six Objectives, this research achieved useful insights against each.

1. Conducted social scientific research drawing on regulator databases to understand longitudinal noncompliance trends. This project confirmed Objective 1, the reliability of the data, which was previously unknown (see project *Results Stage 2*).
2. Resultantly, Objective 2 required analysis of existing regulator-held Blue Swimmer Crab noncompliance datasets to reveal trends, was also successfully achieved (see project *Results Stage 2*).
3. Perceptions survey data collected enabled insights into recreational Blue Swimmer Crab fisher's attitudes towards compliance in WA and SA, confirming and furthering Objective 3 (see project *Results Stage 3*).
4. Drawing on criminological theory, we were able analyse drivers of noncompliance through quantitative data analysis, however qualitative data yielded from recreational fisher perceptions was too unreliable to estimate the extent of illegal catch against Objective 4. An alternative approach to understanding and estimating the illegal component of recreational Blue Swimmer Crab fishing remains elusive.
5. Objective 5 confirmed this proof of concept of the methodology, combining quantitative regulator-held noncompliance datasets and perceptions surveys to better understand trends and gaps in the strategies to address noncompliance. These outcomes can help guide strategies of compliance, however as this project was a pilot, it would require longitudinal evaluation to assess any impact of improvements made to the strategy to fully meet Objective 5. Nonetheless, this evidence-based methodological approach could be usefully applied in other jurisdictions and fisheries (see project *Recommendations* and *Extension and Adoption*).
6. Finally, the perceptions survey provided insights into Objective 6, useful to guide education and enforcement strategies (see project *Results Stage 5*).

Implications for relevant stakeholders

This research reveals evidence-based strategies to better understand gaps and opportunities that can optimise compliance in recreational fisheries. The results are not limited to this fishery and these two jurisdictions. It also confirms that drawing on criminology to inform strategies of fisheries noncompliance approaches, is sensible. However, it is acknowledged that the regulator-held datasets and survey data results represent a small sample of crab fishers and may not be truly reflective of all crab fisher behaviours and/or recreational fisher behaviour more broadly.

Recommendations

Drawing on regulator-held noncompliance datasets coupled with public perceptions surveys of recreational fishers, this research provides a methodological approach, that draws on criminological theory, to identify gaps and opportunities and uses an evidence-base to guide strategies to address recreational fisheries noncompliance. While longitudinal evaluation would be necessary to confirm impact, this research suggests that by revealing compliance gaps can create opportunities to enhance education and enforcement strategies, while balancing recreational fisher enjoyment.

Keywords

Blue Swimmer Crab *(Portunus armatus)*, recreational fisheries, Peel-Harvey Estuary, Western Australia, South Australia, compliance, criminology

Introduction

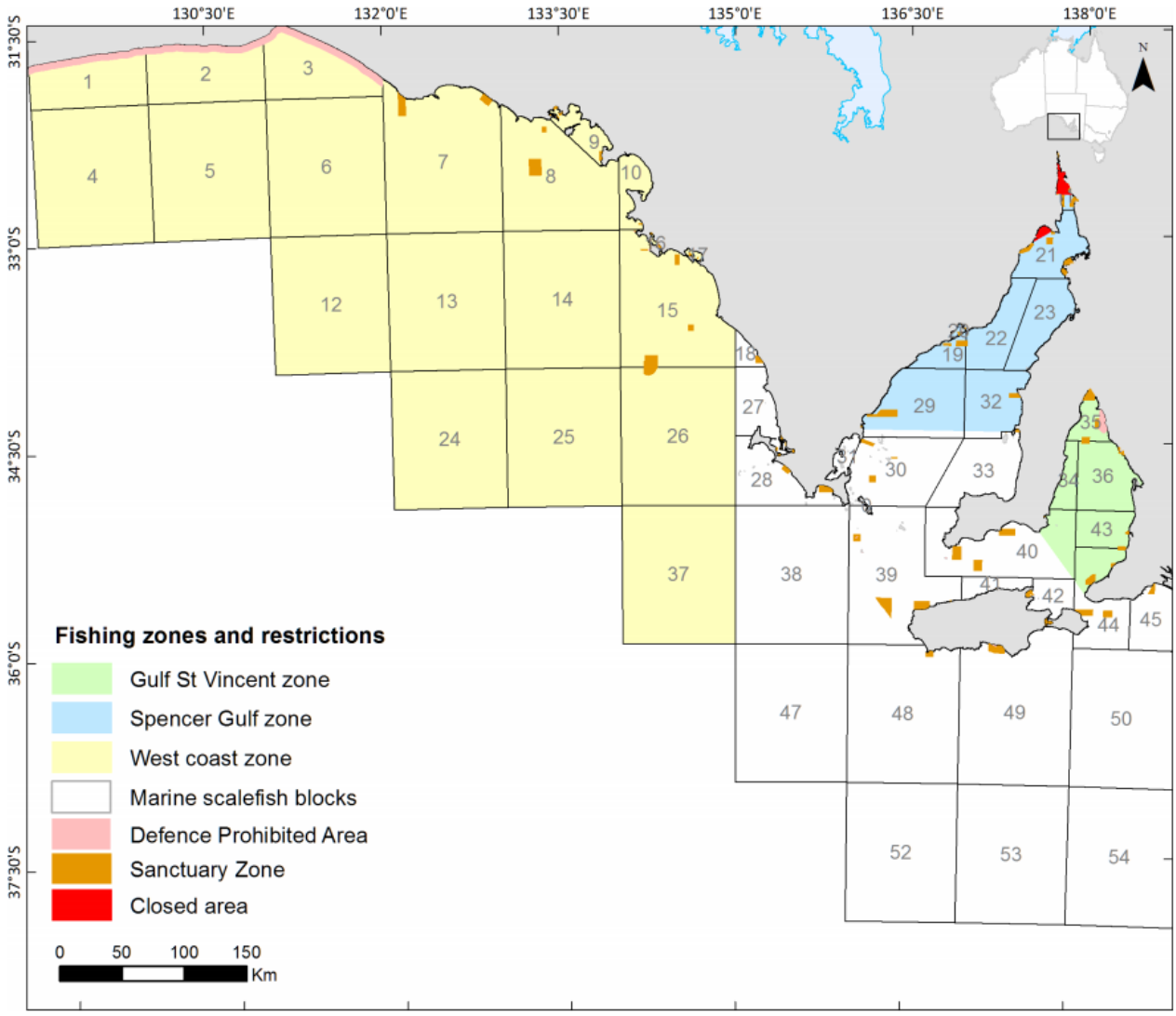
Background

Fisheries management agencies across Australia have primary responsibility to conserve, sustainably develop and equitably manage fish resources. Relevant fishing activities in Western Australia (WA) and South Australia (SA) include commercial, recreational and customary fishing, managed by the Western Australian Department of Primary Industries and Regional Development (DPIRD) and the South Australian Primary Industries and Regions South Australia (PIRSA). Recreational fishing is very popular in WA and SA, but noncompliance research receives less attention than other recreational fisheries sectors.

Compliance in the fisheries sector is often considered from a stock management and economic perspective. To manage recreational noncompliance, there needs to also be a triangulated approach that also considers the human dimension of compliance, including the motivations and behaviours of participating fishers. Commonly, the formation of law is used as a means of control, while it has a very important role to play, it should be assumed that not all participants in the fishery will rationally comply (Bova et al., 2017; Schlager, 2002). Understanding the *how* and *why* of noncompliance through perspectives of other disciplines such as criminology, and directing resources at minimising opportunity, may be an important part of the compliance puzzle (Hauck, 2008). Hauck's (2008) South African study suggests that traditional law enforcement approaches to deter noncompliance need rethinking to achieve sustainable fisheries, which is the focus of this research.

Blue Swimmer Crab recreational fisheries in WA and SA

Blue Swimmer Crabs (*Portunus armatus*) are found throughout the inshore waters of South Australia (SA) (see Map 1), with fishing zones in Spencer Gulf, Gulf St Vincent and West Coast (Svane & Hooper, 2004). Blue Swimmer Crabs are also distributed along the entire Western Australian coast mainly between Nickol Bay and Dunsborough, with the vast majority of recreational fishing taking place in the estuaries and coastal embayments from Geographe Bay to the Swan River and Cockburn Sound (see Map 2) (Fletcher, Mumme & Webster, 2017). The recreational fishing sector is very popular in both South Australia and Western Australia (WA), with recreational fishers harvesting a significant proportion of the total catch of Blue Swimmer Crabs (Fletcher et al., 2017; PIRSA, 2018a). Testament to the importance of recreational Blue Swimmer Crab fishing in these states, in 2016, the Peel-Harvey Blue Swimmer Crab fishery became the first recreational fishery to become Marine Stewardship Council (MSC) certified (Fletcher et al., 2017). MSC certification is based on the three broad principles of: sustainability of the fishery, the environmental impact of fishing, and governance and management of the fishery. The latter principle involves a measure of the fisheries' compliance and enforcement regime (Department of Fisheries, 2016).



Map 1. South Australia Marine Scalefish Fishery fishing zones; the Gulf St Vincent and Spencer Gulf zones are part of the Blue Crab Fishery

Map 2: Peel-Harvey Estuary, Western Australia

WA Peel-Harvey and SA Blue Swimmer Crab recreational fisheries are iconic, accessible and popular fisheries. A licence is not required, and fisheries/compliance officers check for compliance with regulations, as well as having a role in providing education and to ensure the participating fishers are informed of rules to enable and encourage compliance within the fishery. Without which, the expectation of rational compliance with rules for a common resource is unrealistic (Schlager, 2002). These fisheries present a challenge: minimising management costs and restrictions while maximising recreational fisher enjoyment can be conflicting aims, while maintaining a sustainable fishery. As such, there is a clear need to identify optimal regulator- and recreational fisher body[2]-led education and enforcement strategies that can be demonstrated to work well in improving awareness of fisheries regulations and therefore reducing noncompliance in a recreational context of low inspection coverage. A cryptic fisher population that lacks licensing or

[2] Such as Recfishwest https://recfishwest.org.au/ or RecFish SA https://recfishsa.org.au/

registration requirements to target education compounds the challenge. Optimising 'cooperative compliance'[3] in a fishery should consider the perspectives of those paying management costs (taxpayers), those tasked with management (managing government agencies) and recreational fishers themselves, yet little formal study exists of the perceptions of the effectiveness of recreational fisheries rules and their impact on the overall fishing experience.

Research of this kind has not previously been undertaken in WA, SA and indeed Australia, but builds on the existing body of criminological knowledge on offender motivations, underpinned by relevant theory. Drawing on the WA Peel-Harvey and SA Blue Swimmer Crab fisheries as case studies, this research considers how best to optimise compliance within these fisheries. The results from the research intend to guide improved strategies to achieve compliance in these fisheries, through education and enforcement.

Theoretical underpinning

The use of criminological theory is relevant to this research as it can explain noncompliance activities and usefully inform responses. *Crime opportunity theory* is an overarching umbrella concept under which a range of criminological theories sit. This research employed the use of these theories[4] to assess the effectiveness of current education and enforcement approaches[5] and identify novel approaches[6] to compliance in these WA and SA fisheries. Crime opportunity theories provide an alternate view from the traditional offender-focused criminology, instead relying on environmental changes to assist in analysing a situation and finding avenues to develop focused target hardening strategies to reduce opportunities for offending and therefore prevent crime. Focusing on altering the environment (for example physical access to, and visibility of popular fishing locations) rather than just the individual, is appropriate for these fisheries as little information is known about the recreational fishing participants.

For licensed fisheries, participant demographic data is collected, including gender, age, and address, among other categories, however for a licence-free fishery such as the WA and SA shore-based Blue Swimmer Crab fisheries, information is not collected about recreational participants, unless an incident of noncompliance is recorded or as part of a regulator-led survey. It is important to note, noncompliance instances data do not necessarily provide a representative sample of all recreational fisher participants, whether compliant or noncompliant. As such, theoretical underpinnings that focus on the environment rather than the offender are necessary.

In Stage 2, the quantitative stage of this research project, deterrence theory was applied. Specifically, deterrence theory provides a suitable way to understand how best to prevent noncompliance activity going forward. Deterrence theory is based on the premise that people will commit crimes (or fail to comply) if the opportunity exists, unless punishments are *swift*, *certain* and appropriately *severe* (Brisman & Carrabine, 2017). As such, approaches to deter noncompliant behaviours must outweigh the benefits. The fear of punishment can be a suitable deterrent, however it rests on law enforcement interrupting the activity and the courts imposing a sufficient penalty (Brisman & Carrabine, 2017). Further, *specific* (individuals) or *general* (the community at large) deterrence can be applied to offenders through penalties and overarching responses to crime. A deterrence theoretical underpinning thus forms the basis to education and enforcement responses

[3] The concept of 'cooperative compliance' is a well-established concept in the financial services industry, given the complexity of regulations as a voluntary measure for the private sector to collaborate with regulators to prevent situations of tax noncompliance. For this study, we define cooperative compliance as a method to balance enhanced fisher compliance with recreational fisher enjoyment. This novel approach seeks to empower fishers to embrace and encourage a sustainable relationship with recreational fisheries for themselves, their family and community. While cooperative compliance can only be effective if it does not increase management risks for the regulator, achieving it can reduce management costs to the taxpayer while maintaining a sustainable fishery.

[4] See Introduction Stage 1 and Results Stage 5 of this report.

[5] See Results Stage 4 of this report.

[6] See Results Stage 5 of this report.

to noncompliance activities. Analysing current education and enforcement strategies aimed at deterring noncompliance can lead to opportunities for enhancement and in turn, reduced noncompliance.

For Stage 3, the qualitative stage of this research project, situational crime prevention was applied. Situational crime prevention is a concept that seeks to alter the environmental opportunities for offending in particular settings, acknowledging that motivation to offend (or noncomply) will continue to exist (Clarke, 1997). This approach suits fisheries, where minor offending is often dealt with administratively rather than criminally, and efforts to target harden in both WA and SA are communicated through education to encourage compliance as well as strong approaches in enforcement (the carrot *and* the stick approaches).

Applied specifically to the WA and SA Blue Swimmer Crab fisheries, deterrence theory and situational crime prevention can assist in strategising the most appropriate responses to best optimise compliance (Australian Fisheries Management Forum, 2016).

Layout of the report

This report is divided into six sections. Following this introduction is the Objectives section, then the Method in which each Stage of the project is set out. Then follows the Results sections, divided into three stages. Stage 1 involves the environmental scan of relevant compliance literature and the WA and SA regulatory frameworks to understand the context underpinning the research. Stage 2 provides a summary of the trend results of analyses into regulator-held quantitative noncompliance datasets for both WA and SA, against Objectives 1 and 2. Stage 3 of the report details a summary of qualitative public perceptions survey results relating to recreational Blue Swimmer Crab fisher compliance, against Objectives 3, 4 and 6.

The Discussion section of the report brings the collective findings together in Stage 4, which provides a review of current approaches and Stage 5 draws together results from the previous stages to understand *how* and *why* approaches to address noncompliance can be optimised, against Objective 5.

The Implications section then provides an overview of the usefulness of the findings, also against Objective 5, before the Conclusion. The final sections of the report include Recommendations and Extension and Adoption Plan, which are outlined in abstract to enable fisheries and jurisdictions beyond those within this study to maximise benefit from the results. Finally, the Appendices include A) a matrix of the online survey; B) the write up the quantitative results of the project (submitted for publication, currently under review); and C) the write up of the qualitative results of the project (accepted for publication).

Objectives

This study had six objectives:

1. To characterise the quality and contents of compliance datasets held by WA and SA government agencies and specific to two recreational Blue Swimmer Crab fisheries, in order to evaluate their adequacy for social science research objectives such as longitudinal studies.
2. To analyse existing Blue Swimmer Crab compliance datasets for trends and insights and test those findings against reference groups.
3. To contrast recreational Blue Swimmer Crab fisher's attitudes towards compliance in WA and SA to their own, and the other jurisdictions' management frameworks.
4. Determine whether illegal catch can be estimated based on assessment of available data and analysis of drivers of noncompliance.
5. To conduct a proof of concept that scopes out the resources, expertise and design necessary to show changes in Blue Swimmer Crab fisher behaviour and attitudes and demonstrate any causality to education and enforcement strategies and their effect on 'cooperative compliance'.
6. To better understand how recreational Blue Swimmer Crab fishers in both jurisdictions obtain information and respond to education and enforcement strategies.

Method

To better understand strategies to encourage compliant participation among recreational fishers, this project involved five stages:

1. **Environmental scan** – this involved a) a review the existing literature on fisher attitudes to compliance and its impact on the fishing experience in those fisheries and recreational fisheries more generally; and b) a desktop review of government reports, legislation and use of project team expertise to compare, contrast and summarise the two regulatory regimes using consistent terminology. The specific methodology for the literature search analysis is expanded below in Stage 1.
2. **Quantitative research** (Objectives 1 and 2) – UWA researchers critically analysed anonymised operational data sources between 2009 and 2019 held by regulators, DPIRD and PIRSA for the recreational Blue Swimmer Crab fishery, to determine specifically catch and effort, and inspection and offence data. Where possible, trends in noncompliance activities (for example individual demographics, spatial, temporal etc.) within each jurisdiction, and comparisons between the jurisdictions were generated and interpreted to understand nuanced differences in noncompliance activities in the fishery. Longitudinal changes in noncompliance were considered against known policy and legislative changes. These data were presented to the project steering committee[7] for expert validation. The specific methodology for the quantitative analysis is expanded below in Stage 2.
3. **Qualitative research**[8] (Objectives 3 4 and 6) – COVID-19 halted the plan to hold focus groups to test dataset findings against stakeholders, instead UWA researchers collected attitudinal/perception data from online surveys developed in Qualtrics. The survey was disseminated among peak body representatives, fisheries education officers, fisheries enforcement officers, fisheries managers and the public, including recreational fishers. This survey sought to obtain a cross-section of recreational fisher stakeholder views about personal perceptions of compliance and regulation of fishery resources, incentives and barriers to participation, as well as introducing the concept of, and gauging support for 'cooperative compliance' within these two fisheries as a means to limit noncompliance. We also sought to understand perceptions on illegal take estimates, however these perceptions yielded from the surveys were not deemed useful as it failed to generate any meaningful results, and were discarded from analyses. Future research may need to consider alternate approaches to generate meaningful estimates of illegal fishing. Culturally and linguistically diverse groups were not identified through these surveys, though future studies may benefit from capturing data on subpopulations. Comparisons were not possible between WA and SA due to stark variations in survey participant numbers. The specific methodology for the qualitative analysis is expanded below in Stage 3.
4. **Review** (Objective 5) – Based on the qualitative and quantitative data yielded from the datasets and surveys, collectively, these data enabled us to apply criminology theories to understand the potential effectiveness of education (such as communication with the public of catch and size limits, provision of size gauges etc.) and enforcement management interventions (such as fisheries officer patrols and issuance of warnings and infringements etc.) in the two Blue Swimmer Crab fisheries, taking into account the effectiveness of prior compliance strategies. These interpretations acknowledge that the

[7] The project steering committee included Mr Leyland Campbell, RecFishWest; Dr James Tweedley, Murdoch University; Mr John Looby, DPIRD (Retired); and Mr Anthony Chen, New South Wales Department of Primary Industries. The project steering committee discussed results and project progress partway and at the end of the project.
[8] Due to COVID-19, planned professionally-moderated focus groups in Western Australia and South Australia were replaced with online surveys due to government-mandated travel restrictions and physical distancing making the planning and logistics of focus groups during 2020 and 2021 unviable.

regulator-held datasets and survey data results represent a small sample of crab fishers and may not be truly reflective of all crab fisher behaviours and/or recreational fisher behaviour more broadly.

5. **Summation** – By analysing the noncompliance datasets and behavioural trends, we identified educational approaches and enforcement strategies that could improve compliance outcomes by enhancing 'cooperative compliance' from fishers, balancing recreational fisher enjoyment while taking into account management costs, without increasing management risks for WA and SA Blue Swimmer Crab fisheries.

Results and Discussion

This section of the report synthesises a summary of results and discussion from throughout the five Stages of this project.

Stage 1: Environmental Scan

While fisheries research in the SA and WA Blue Swimmer Crab commercial and recreational fisheries is routinely undertaken (see for example Beckmann & Hooper, 2022; Johnston et al., 2020), motivational and behavioural trends leading to regulatory noncompliance receives less research attention. Broader research exists that considers fishers' perceptions and attitudes towards compliance from an economic, social and ecological perspective.

Noncompliance in WA and SA

Recreational fishing is a cherished pastime worldwide that is an important part of the culture and fabric of many societies, however noncompliant fishing activity must be appropriately dealt with to prevent broad-ranging harms. Increasingly, fisheries management agencies are managing beyond sustainability, as their oversight extends to managing competing allocations and rights between different groups and external pressures such as environmental stressors and market forces. As such, a range of management strategies may be adopted to control the fishery, including licences for fishers and fishing vessels, effort and gear restrictions, spatial and temporal closures, restrictions on sale and supply of fish and fish products, quotas and catch limits, management regimes for specific fisheries, protected species and reserve areas, as well as a range of penalties for breaches. Restrictions are often underpinned by stock assessments, which rely in part on reported commercial catches and surveyed recreational users. In licence-free fisheries, assumptions and stock estimates may need to be heavily relied upon. While stock estimates are usually conservative enabling some margin of error, high levels of noncompliance can invalidate assumptions about catch and effort and undermine sustainable management goals. Therefore, to maintain sustainable, equitable fisheries, effort to limit noncompliance is essential.

Noncompliant fishing activity of Blue Swimmer Crabs in the Peel-Harvey Estuary (WA) has been a major concern over the study period (Department of Fisheries, 2010, 2011, 2012, 2013, 2014, 2015a, 2016, 2017; Department of Primary Industries and Regional Development, 2019). High rates of prosecutions and infringements are attributable, in part, to a strong enforcement presence. The Peel-Harvey Estuary blue swimmer fishery has been identified as having the highest level of noncompliance in WA; taking undersize crabs in the Estuary has comprised around 20 percent of all recreational fishing offences in WA annually (Department of Primary Industries and Regional Development, 2018).

The prominence of taking undersize crabs in the context of noncompliance in WA Blue Swimmer Crab fisheries is also reflected in media reports. While not all noncompliance is reported in the media, on occasion, cases are reported to publicly deter would-be noncompliers. For example, in December 2018, it was reported that a Mandurah woman found 15 cooked undersized crab shells and that it was a common occurrence for her to find discarded undersized shells (Hildebrandt, 2018b). In March 2018, three men in Mandurah were found guilty of possessing 4, 5, and 39 undersized crabs, respectively (Hildebrandt, 2018a). Other noncompliant behaviours have also been reported in the media. In November 2015, it was reported that commercial Blue Swimmer Crab fishers in the Peel-Harvey and Mandurah regions had complained of thefts from crab pots and damaged fishing gear, which was attributed to recreational fishers struggling to catch crabs early in the season (Fitzgerald, 2015). More recently, 10 people were reportedly prosecuted for taking large numbers of undersized Blue Swimmer Crabs in the Mandurah region. A group of four of these fishers were reported to have taken over 100 crabs, with 96 of the crabs undersized (Kirby, 2020).

Noncompliance for recreational fishing of Blue Swimmer Crabs in SA have also been reported in the media, with noncompliance activities identified including undersize crabbing and exceeding bag and boat limits (Primary Industries and Regions South Australia, 2015). In September 2018, a group of three people had been found with 100 undersized Blue Swimmer Crabs (Etheridge, 2018). More recently, north of Adelaide a man allegedly possessed 126 Blue Swimmer Crabs, 124 of which were undersized (Basham, 2020).

Regulatory review

Overarching legislation provides governance for the fishery in each jurisdiction. In WA, the *Fish Resources Management Act 1994* and the Fish Resources Management Regulations 1995 provide a comprehensive suite of fishery management tools for Blue Swimmer Crab fishing in WA, including the Peel-Harvey Estuary. In SA, the *Fisheries Management Act 2007* and the Fisheries Management (Blue Crab Fishery) Regulations 2013 are the overarching instruments for the Blue Swimmer Crab fishery. Table 1 provides a comparative matrix of operational, enforceable management tools.

Table 1. Summary of Blue Swimmer Crab Management Tools, Western Australia and South Australia, as at 2022

Management Tool	Purpose	SA Implementation	WA Implementation
Catch Limit	To limit catch taken per fisher, sharing the resource and contributing to the sustainable management of the fish stock.	20 – combined limit with Sand Crabs Daily boat limit when 3 or more people are crabbing on board: 60 – combined limit with Sand Crabs	Ranges from 5-20* based on fishing location. In the West Coast bioregion the limit is 10. A boat limit of 20 crabs also applies**
Size Limit	Allow fish to reach maturity to complete their breeding cycle.	11 cm measured across the carapace from the base of the largest spines.	Crabs taken must be at least 127 mm across the widest part of the carapace.
Spatial Closures	To create sanctuary areas of unfished habitat, for stock, habitat or ecosystem protection.	Nil.	Cockburn Sound is closed to crabbing. No crabbing in any Marine Park Sanctuary Zone, but no SZs in the Peel-Harvey Estuary.
Temporal Closures	To remove fishing effort during certain times of the day or year.	Nil.	Closed from 1 September to 30 November (since 2019, prior to that was 1 September to 31 October).
Additional Breeding Stock Protections	To enhance the breeding stock by requiring vulnerable and valuable fish to be returned to the water unharmed.	Females with external eggs are totally protected and must be returned to the water immediately.	Egg-carrying ('berried') females must be returned to the water immediately, before attempting to catch another crab
Gear Design Restrictions	To minimise harmful effects to fish and ecosystems. To allow targeting of certain size classes. To decrease catch per unit effort by making fish harder to catch.	Baiting: When using hoop nets or drop nets in marine waters (including from a jetty or boat) you cannot use any type of meat, chicken or other poultry in hoop nets or drop nets. See the bait and berley guidelines for more information.	Dredges or rakes, obstructions, nets, poisons, explosives, traps, pots, set-lines, hooks and sharp implements and commercial fishing gear are prohibited in the fishery.
Reporting Requirements	To enable better understanding of catch and effort by those managing	Nil.	Nil.

	the fishery and the fish stock it depends on.		
Restriction on sale and barter	To maintain resource equity with commercial fishers. To deter people from taking catch for reasons other than enjoyment of the fishing experience and consumption of fresh seafood.	It is an offence for recreational fishers to sell or trade their catch.	It is illegal for recreational fishers to sell or barter their catch.
Licence requirements	To create reciprocal obligations between those with a fishing right, and those who pay for fishery management. To identify people authorised to undertake fishing activities. To provide revenue to help cover the costs of management.	Nil.	If a powered boat is used to fish for crabs or to reach the fishing location, at least one person on board needs a Recreational Boat Fishing Licence.
Possession restrictions	Restrictions applied to how catch is stored and transported when fishing is not underway.	Nil.	All uncooked crabs must be kept in whole form, unless being prepared for immediate consumption.

*there are also limits on the number that can be female in some locations
**each individual is only allowed the daily bag limit and must hold their own boat licence
***there are also limitations on the amount of gear that is permitted for use at any one time
Source: DPIRD, 2020; PIRSA, 2019a

Changes to compliance regulations

The following is a timeline of recent changes to compliance regulations relevant to recreational Blue Swimmer Crab fishing in WA and SA:

- 2019: From Swan River to Minninup Beach (WA), the seasonal closure was extended by a month to cover three months (1 September and 30 November). For the Swan and Canning Rivers (WA), a new bag limited of 5 crabs per fisher was introduced. For Geographe Bay (WA), a maximum of 5 female crabs for each 10 crab bag limit per fisher was introduced (DPIRD, 2019)
- 2014: Cockburn Sound (WA) was closed to fishing (Department of Fisheries, 2015b)
- 2013: High tier infringements (up to $1,000) introduced in WA to more effectively deal with mid-range offences without the need to take a matter to court, if the offender accepted the fine. Intended to deliver a swifter way of dealing with mid-range matters and reduce the time spent by compliance officers compiling prosecution briefs, getting them back on patrol more quickly.
- 2013: Gulf St Vincent (SA) bag limits were halved from 40 per person to 20 per person, and from 120 per boat to 60 per boat (PIRSA, 2015)
- 2012: The Cockburn Sound (WA) fishing season was extended to 31 July (Fletcher & Santoro, 2013)
- 2010: In WA, a Recreational Fishing from Boat Licence was introduced restricting catch to 20 crabs per powered boat when there are two or more people holding a licence, and 10 crabs if only one person holding a licence. The Cockburn Sound (WA) fishing season was extended to 30 April (Fletcher & Santoro, 2012)
- 2009: Cockburn Sound (WA) was re-opened with a crab size limit of 127 mm and a limited season from 15 December to 31 March (Fletcher & Santoro, 2012)
- 2007: The West Coast bioregion (WA) bag limits were halved from 20 per person to 10 per person, and from 40 per boat to 20 per boat. A Peel-Harvey Estuary (WA) seasonal closure was introduced for the months of September and October (Fletcher & Santoro, 2010)

Current compliance strategies

South Australian and Western Australian Blue Swimmer Crab fisheries operate similar compliance programs. In SA Blue Swimmer Crab fisheries, PIRSA operates a compliance program with two overarching objectives: to maximise voluntary compliance with fisheries rules; and to create effective deterrence to breaching fisheries rules. In WA, the primary compliance program objective of the Department is to encourage cooperative compliance by 'delivering a comprehensive awareness and education program to improve awareness of the legislation, and to increase people's ability to willingly comply with the regulatory requirements' (Department of Primary Industries and Regional Development, 2022). An Operational Compliance Plan is developed for each fishery in both the SA and WA jurisdictions; in WA the primary objective of the plan is to encourage cooperative compliance, while in SA it is to ensure compliance operations are intelligence driven, focussed on outcomes and cost effective (Department of Fisheries, 2015b; Department of Primary Industries and Regional Development, 2022; PIRSA, 2015).

South Australia

Current compliance strategies employed by PIRSA and targeted towards Blue Swimmer Crab recreational fishers are broken down into: education and awareness measures, deterrence measures, and enforcement measures (PIRSA, 2015).

Education and awareness measures include:

- Providing information on fishing regulations through printed material (e.g. Recreational Fishing Limits brochure, signage at popular fishing spots, PIRSA website), the Recreational Fishing Smartphone App, media releases, the Fishwatch reporting and information hotline and SMS fish;
- Developing partnerships with schools and other educational institutions;
- A Fishcare Volunteer program delivering education services at various shows and field days; and
- Fisheries Officers and Fishcare Volunteers patrolling popular fishing locations and disseminating educational material about fishing regulations.

Deterrence measures include:

- Catch inspections on land and water (body worn cameras for Fisheries Officers have also been used) (PIRSA, 2017); and
- Published media articles about compliance activities.

Enforcement measures include:

- Conducting intelligence driven covert and overt operations; and
- Addressing noncompliance with issuance of cautions, expiations and prosecutions before court.

Western Australia

The current compliance strategies employed by PIRSA are largely mirrored in the management of Blue Swimmer Crab fisheries in WA. For example, in the Peel-Harvey Estuary (WA), the current compliance strategies for the recreational sector involve Fisheries and Marine Officers conducting:

- Land and water patrols;
- Catch, gear and licence inspections;
- Covert surveillance of persons of interest under approved operations; and
- Road-side checkpoints (Department of Fisheries, 2015b)

Other notable compliance strategies delivered more broadly across WA Blue Swimmer Crab fisheries have included:

- A Fisheries Volunteer program providing education about fishing regulations, conducting beach patrols, and attending events such as school talks and fishing workshops (Fletcher & Santoro, 2010);
- The delivery of targeted education programs throughout the West Coast region by the Department's Marine Discovery West education team (Fletcher & Santoro, 2011);
- Close co-operation with the Shire of Murray and the City of Mandurah who manage the land and infrastructure around the estuary.
- On site education presence at strategic high volume fishing locations and at key events such as the Mandurah Boat Show.
- The distribution of free crab gauges in the Peel-Harvey Estuary (Department of Fisheries, 2015a); and
- Provision of information through high profile signage, posters, information flyers and other advertising. The Department also provides information through multi-lingual publicity materials, brochures, weblinks, community newspaper advertising, and advertising on a Chinese community website (Department of Fisheries, 2011, 2013, 2015a, 2016).

Evidence-based compliance in commercial and recreational fisheries

Theoretical overview of noncompliance: Rationalist and normative perspectives

Understanding compliance in fisheries has traditionally focussed on the rationalist perspective that individuals weigh up the potential benefits of violating regulations with the probability of detection and size of possible sanctions (Becker, 1968). From this perspective, the probability of detection and severity of sanction, or in other words, enforcement, is viewed as the primary source of compliance (Hønneland, 1999). Though sharing similarities with rational choice theory in the field of criminology, it is important to highlight that the two approaches are different. While the economic analysis of compliance assumes perfect rationality, rational choice theory recognises that individuals make immediate decisions with imperfect information, so called 'bounded rationality' (Cornish & Clarke, 1987). In the context of fisheries, rational choice theory stipulates that the decision to violate compliance regulations is based on the effort of catching fish, the expected reward of catching fish beyond the prescribed legal limits, the probability of being caught, and the severity of the penalty in the event of being caught (Hønneland, 1999; Petrossian, 2015). Additionally, routine activity theory (Cohen & Felson, 1979) predicts that the spatial and temporal location to engage in noncompliant fishing is not random, but based on the situational opportunities available to the offender (Petrossian, 2015). Together, rational choice theory and routine activity theory provide the foundation of the situational crime prevention approach. The situational crime prevention framework provides 25 techniques that can be applied to mitigate crime opportunities and therefore reduce noncompliance, see Table 2 (Clarke, 1980). The 25 techniques map out to the broader crime reduction strategies of reducing rewards, increasing risks, increasing effort, removing excuses, and reducing provocations, which are seen to alter an offender's decision-making (Cornish & Clarke, 2003).

Table 2: The 25 Techniques of situational crime prevention

Increase the Effort	Increase the Risks	Reduce the Rewards	Reduce Provocations	Remove Excuses
1. Target harden ▪ Steering column locks and immobilisers ▪ Anti-robbery screens ▪ Tamper-proof packaging	**6. Extend guardianship** ▪ Take routine precautions: go out in group at night, leave signs of occupancy, carry phone ▪ "Cocoon" neighborhood watch	**11. Conceal targets** ▪ Off-street parking ▪ Gender-neutral phone directories ▪ Unmarked bullion trucks	**▪ 16. Reduce frustrations and stress** ▪ Efficient queues and polite service ▪ Expanded seating ▪ Soothing music/muted lights	**21. Set rules** ▪ Rental agreements ▪ Harassment codes ▪ Hotel registration
2. Control access to facilities ▪ Entry phones ▪ Electronic card access ▪ Baggage screening	**7. Assist natural surveillance** ▪ Improved street lighting ▪ Defensible space design ▪ Support whistleblowers	**12. Remove targets** ▪ Removable car radio ▪ Women's refuges ▪ Pre-paid cards for pay phones	**17. Avoid disputes** ▪ Separate enclosures for rival soccer fans ▪ Reduce crowding in pubs ▪ Fixed cab fares	**22. Post instructions** ▪ "No Parking" ▪ "Private Property" ▪ "Extinguish camp fires"
3. Screen exits ▪ Ticket needed for exit ▪ Export documents ▪ Electronic merchandise ▪ tags	**8. Reduce anonymity** ▪ Taxi driver IDs ▪ "How's my driving?" decals ▪ School uniforms	**13. Identify property** ▪ Property marking ▪ Vehicle licensing and parts marking ▪ Cattle branding	**18. Reduce emotional arousal** ▪ Controls on violent pornography ▪ Enforce good behavior on soccer field ▪ Prohibit racial slurs	**23. Alert conscience** ▪ Roadside speed display boards ▪ Signatures for customs declarations ▪ "Shoplifting is stealing"
4. Deflect offenders ▪ Street closures ▪ Separate bathrooms for women ▪ Disperse pubs	**9. Utilize place managers** ▪ CCTV for double-deck buses ▪ Two clerks for convenience stores ▪ Reward vigilance	**14. Disrupt markets** ▪ Monitor pawn shops ▪ Controls on classified ads ▪ License street vendors	**19. Neutralize peer pressure** ▪ "Idiots drink and drive" ▪ "It's OK to say No" ▪ Disperse troublemakers at school	**24. Assist compliance** ▪ Easy library checkout ▪ Public lavatories ▪ Litter bins
5. Control tools/ weapons ▪ "Smart" guns ▪ Disabling stolen cell phones ▪ Restrict spray paint sales to juveniles	**10. Strengthen formal surveillance** ▪ Red light cameras ▪ Burglar alarms ▪ Security guards	**15. Deny benefits** ▪ Ink merchandise tags ▪ Graffiti cleaning ▪ Speed humps	**20. Discourage imitation** ▪ Rapid repair of vandalism ▪ V-chips in TVs ▪ Censor details of modus operandi	**25. Control drugs and alcohol** ▪ Breathalyzers in pubs ▪ Server intervention ▪ Alcohol-free events

Source: Cornish & Clarke, 2003

Alternatively, the normative perspective applies a more sociological model of compliance to ensure it takes into account fisher's personal morality and perceived legitimacy of the enforcing authority (Tyler, 1990). In this model, both policing and self-regulation are used as tools for enforcement, and a monetary fine and social-stigma component are used as tools for deterrence (Byers & Noonburg, 2007). It is important to emphasise that while the importance of moral obligation as a source of compliance is highlighted under this perspective, enforcement is still considered a necessary measure (Arias et al., 2015; Hønneland, 1999). Importantly, enforcement and obligation are considered management-induced sources of compliance and therefore manipulable to achieve target compliance levels, though obligation is only deemed manipulable over a longer time frame (Hønneland, 1999).

The following overview will proceed with a consideration of the evidence for the compliance strategies supported by the rationalist perspective, the normative perspective, and finally, the more contemporary situational crime prevention approach, in the fisheries context, specifically.

Theoretical analysis of noncompliance: Rationalist perspective

Early research into compliance in fisheries involved econometric research modelling optimal levels of enforcement in protected fishing reserves (see for example Milliman, 1986; Sutinen & Andersen, 1985). A key finding arising from more recent econometric models is that an initial increase in enforcement (more resources and effort invested in protecting the reserve) has a strong positive effect on compliance, however as the abundance of potential catch in the reserve increases (less fisher effort and greater expected reward) there is a subsequent diminishing effect on compliance; in this event, a significant level of enforcement is required to achieve complete compliance (Byers & Noonburg, 2007; Coelho et al., 2013). At the efficient stock population size, the marginal benefit to fishers is equal to the marginal cost of enforcement; in other words, in fisheries that necessarily place restrictions on catch, an equilibrium should be reached where fisher benefit is proportional to the enforcement effort (Coelho et al., 2013); this, in turn, would ensure that the

financial cost of enforcement is also reflected in fishery policies on compliance (Arnason, 2006). Traditional measures such as gear restrictions, closed seasons, and total quotas are seen to increase fishing effort to the detriment of expected benefits (Anderson, 1989), whereas the level of effort required for, and expected benefit of noncompliance avoidance activities might present a more favourable proposition to fishers; this suggests that a strong enforcement effort is therefore necessary to ensure compliance.

Empirical analysis of noncompliance

In consideration of empirical research into compliance of fishery regulations, it is necessary to highlight the importance of measuring noncompliance accurately as this serves to quantify the crime problem and provide the input needed to understand how to address the problem. A systematic review synthesising data from 63 marine reserves throughout the world found that the majority of information on compliance in the literature relating to fisheries was qualitative rather than quantitative (Bergseth et al., 2015). Of the qualitative data, the majority was in the form of anecdotal statements, while post-hoc information and expert opinion were also frequently recorded measures. Of the quantitative data, direct questioning was the most common measure used to estimate noncompliance, while law enforcement records, modelling, direct observation, expert opinion, and indirect questioning were also used. The authors of the systematic review recommended using more than one method to capture and measure noncompliance, as well as ensuring a baseline measure is recorded for comparison (Bergseth et al., 2015). This consideration of the accuracy of noncompliance data has a bearing on the overview of research that follows as well as the development of future management strategies to manage noncompliance in fisheries.

Empirical analysis of noncompliance: Rationalist perspective

The notion that fishers are motivated to violate regulations due to a rational decision that the expected reward and effort involved in noncompliance outweighs the probability of detection and severity of sanction, is borne out in the literature. Importantly, empirical support for enforcement has implications for all of the theories presented in this overview as it is considered necessary to each one.

Expected reward and perceived effort

It has been suggested that recreational fishers principally violate regulations due to “greed and laziness” (Sarti, 2006). The greed of landing a catch beyond the prescribed limits may manifest in financial incentives to illegally sell the catch, or in the personal enjoyment of the additional catch. The financial gain from violation of regulations has long been associated with greater noncompliance (Furlong, 1991). More recently, in a survey of commercial fishers in the United Kingdom, higher quota violations were positively associated with the perception that regulations imposed greater restraints on potential earnings (Hatcher & Gordon, 2005). Moreover, this perception accounted for the most significant factor in the violations model generated (Hatcher & Gordon, 2005). In another study, despite fishers perceiving protected areas as providing general benefits of conflict resolution between static and mobile fishers and sustainability of fish stocks, few fishers perceived that they received personal benefits, and in turn, few fishers stated that protected areas influenced where they fished (Bloomfield et al., 2012).

The second motivation, laziness, is reflected in the perceived effort to comply or not comply with regulations. Noncompliance due to the perceived effort of following regulations is candidly evident in an anecdote recounted in Boonstra, Birnbaum and Bjorkvik (2017) involving a Swedish fisher. The fisher, who was obliged to maintain an electronic logbook due to the size of their boat, refused to on the grounds that: “The paper logbooks have always worked well for me. I don’t want computers and all that”. After receiving a number of fines for his transgressions, the fisher determined to severe the front of his boat, thus reducing its size, and rendering him no longer accountable to the regulation. At the boat’s stem, the fisher wrote: ‘I have been sacrificed for the Swedish bureaucracy’ (Boonstra et al., 2017). Interestingly, this fisher perceived a lesser effort in severing and vandalising their boat than complying with fishery regulations. Crucially, the perception of effort required to comply with the regulation produced a history of noncompliance from this fisher prior to them taking measures to avoid the regulation altogether (Boonstra et al., 2017). Perceived

effort may also be recognised where there is low effort involved in noncompliance such as in a greater abundance of fish available, and a larger protected area with a reduced capacity for enforcement. Larger protected areas have been found to have lower levels of compliance (Arias et al., 2015), and the heavy concentration of fish species in a marine protected area has been identified as attractive to offenders (Weekers et al., 2019). Further, it has been suggested that measures of noncompliance take into account a measure of fisher effort when violating regulations as well as the number of fishers who are noncompliant or the frequency of illegal fishing, as this provides important information about the motivations for offending and a candidate for strengthening enforcement (Arias et al., 2015). Commercial fisher effort may be measured by summing the number of vessel positions within a particular spatiotemporal frame using satellite-based vessel monitoring system data (see for example Bloomfield et al., 2012). For non-licensed shore-based recreational fisheries such as the two Blue Swimmer Crab case studies, effort is more usually estimated using sampling, either directly *in-situ* or by using some form of recall of perceptions of frequency of fishing.

Probability of detection

Early studies investigating the impact of probability of detection on fisher noncompliance, found a strong association between higher probability of detection and lower noncompliance. For example, Furlong (1991) surveying fisher perceptions on probability of detection and self-reported regulation violations, found that a one percent increase in the probability of being detected was predicted to deter around 0.4% of violations. Moreover, probability of detection was found to be a greater deterrent than severity of sanctions in this study (Furlong, 1991).

It has been suggested that the probability of detection requires extensive surveillance, and compliance officers that are sufficiently competent and motivated to sanction violations. Examples where this is lacking include compliance officers that were once fishers and who, as a result, disagree with always following the established procedures, and officers acquainted with the fishing community who consequently embrace a more relaxed stance towards violations (Hønneland, 1999). The notion of having capable guardians in the form of competent and effective compliance officers is supported by empirical research. Separate research examining the effectiveness of compliance strategies in fisheries in South Africa and the Philippines attributed the high rate of noncompliance in these fisheries to a lack of apprehension and conviction of violations (Brouwer et al., 1997; Catedrilla et al., 2012). In Costa Rican fisheries, a low enforcement priority by officers with multiple other duties, was cited as a reason for high rates of noncompliance (Arias et al., 2015), and a low monitoring, control and surveillance effort by officers has also been raised as an incentive for fishers in Greece to violate the law, specifically in relation to taking undersized fish (Damalas & Vassilopoulou, 2013). One possible reason for low rates of noncompliance detection beyond low rates of noncompliance, suggested by King, Porter and Price (2009) in a US fisheries study, is that officers might be compromised in their ability to effectively detect violations due to limited training in searching for and identifying evidence. Training officers in the process of prosecution (e.g. handling, presentation and preservation of evidence) has been raised in other studies as a means of enabling officers to understand formally admissible evidence and strengthening enforcement practices (Akella & Cannon, 2004; Anderson, 1989; Catedrilla et al., 2012), though the ease with which this training can be implemented has been questioned (Anderson, 1989). Other recommendations made in relation to improving compliance through strengthening the probability of detection include: strict implementation of the standard operating procedures of apprehension by compliance officers, regular patrolling by officers, providing officers with cameras and video equipment to document evidence during operations, ensuring officers are more vigilant (Catedrilla et al., 2012), and focussing scarce monitoring resources on individuals identified as more inclined to noncompliance (Anderson, 1989; Arias et al., 2015). For example, in analysing compliance data in specific fisheries, being unemployed (Furlong, 1991), holding prior convictions (Furlong, 1991), being less educated (Bova et al., 2017), being young and male (Fabinyi, 2007), being poor (Cinner, 2009), not being a fishing rights holder (Brick et al., 2012), and being an outsider (Berkes et al., 2006) have all been associated with greater rates of noncompliance.

A more serious matter in the probability of detection is in some jurisdictions is officer corruption. This has been identified as a factor contributing to high rates of noncompliance in Europe and South America (Eggert & Lokina, 2010; Nunan et al., 2018; Sundström, 2012). Another issue faced by compliance officers is that of localised deterrence, whereby fishers learn when and where compliance officers are likely to patrol, and are thereby able to avoid detection (Arias et al., 2016; King et al., 2009). It has been suggested that fishery authorities periodically monitor patrol records to develop patrol approaches that maximise the probability of detection (Arias et al., 2016); it is reasonable to assume that this would involve a calculated patrol strategy based on spatial and temporal frequency of violations, as well as some randomisation built into the patrolling schedule.

Severity of sanction

In relation to sanctions, Hatcher & Gordon (2005) found a strong association between past experiences of convictions and perceived probability of detection in a fishery in the United Kingdom, leading the authors to conclude that, in that particular fishery, securing sanctions and convictions was the most significant deterrent available to fishery authorities. Moreover, they suggested that as well as an increased frequency of inspections by compliance officers, increased quality or thoroughness of inspections may also need to be improved to ensure compliance (Hatcher & Gordon, 2005). Research also supports more severe sanctions for offenders (Gezelius, 2007; King et al., 2009). In a study examining perceptions of fishers and other stakeholders such as management personnel and compliance officers, both groups of stakeholders perceived the large penalty rate as a contributing factor to compliance in the fisheries (Bose & Crees-Morris, 2009). King et al. (2009) found that the deterrent effect of enforcement in US fisheries is enhanced by increasing the rate of detection, the rate at which detected violations are penalised, and the magnitude of expected sanctions. In a Western Australian survey with the majority of respondents being recreational fishers, there was strong support for the use of more severe sanctions for breaches of a range of regulations. For example, 62.9% of respondents believed that more serious offences such as exceeding the bag limit by a large amount, interfering with others fishing gear or selling recreationally or illegally caught fish, should be met with a sanction regardless of their licence category, as well as restrictions placed on their ability to obtain a licence in the future, while only 1.4% believed that no sanctions should apply (Lindley & Techera, accepted in press). Additionally, the most severe sanction option presented to respondents, a permanent licence revocation, was selected by 26.9% in relation to fishers convicted of selling recreational or illegally caught fish, 47.3% in relation to recreational fishers convicted of interfering with other fisher's gear, and 52.8% in relation to fishers convicted of exceeding the bag limit by more than five times the limit (Lindley & Techera, accepted in press). Other effective forms of imposing a more severe sanction on offenders include loss of privileges and graduated sanctions based on number and severity of violations (Bellanger et al., 2019).

Empirical analysis of noncompliance: Normative perspective

Research has also addressed the impact of variables such as peer pressure and social influence on manipulating a fisher's sense of obligation to be compliant. This follows the suggestion that fishery management should seek to increase voluntary compliance (Read et al., 2011), and has the benefit of taking into account the diversity of fisher's responses to regulation and motivations for noncompliance (Boonstra et al., 2017). Moreover, the normative perspective was also introduced in response to some of the pitfalls of enforcement in the fisheries context, such as the notion that judges often advocate penalties that are commensurate to the crime and may therefore not support more severe sanctions (Kuperan & Sutinen, 1998), the complex and cost prohibitive nature of enforcement for widely dispersed recreational fisheries (Sutinen, 1993), and evidence of high levels of compliance in fisheries despite low probabilities of detection and low penalties (Sutinen & Kuperan, 1999). The importance of moral obligation in compliance has been investigated through interviews with fishers. For example, Bose & Crees-Morris (2009) found that 75% of fishers in their survey identified moral obligation as a major factor in their compliance. However, this has not always been replicated; only 20% of fishers in a UK study agreed with the normative view that quotas should

be complied with through a sense of obligation to conserve fish stocks (Hatcher & Gordon, 2005), though consideration may be given to the legitimacy of the rules and of the regulator in such studies.

Emerging from the normative perspective are the management theories of self-management and co-management. In self-management, compliance is secured through the fisher acceptance of the legitimacy of the system instead of appealing to threat of power (Hønneland, 1999). Co-management theory maintains the involvement of state authorities in the management of fisheries, but encourages giving its participants a significant say in the management process such as in designing rules and management procedures (Arias et al., 2015; Brick et al., 2012; Hønneland, 1999). Like self-management perspective, enhanced perceptions of legitimacy in management is attainable through user involvement, and coercion offers only a complementary or even lesser mechanism for ensuring compliance (Hønneland, 1999). Both of these participatory management approaches serve to encourage shared responsibility and stewardship of fishery resources (Bose & Crees-Morris, 2009). A greater involvement of fishers in the decision-making process of regulations has been examined through fisher interviews. Kuperan & Sutinen (1998) found that the more fishers agreed that collective views of fishers were being taken into account in the generation of regulations, the lower their violation rate. More compellingly, a meta-analysis of 55 studies found that stakeholder participation in developing management rules and processes was strongly associated with compliance in protected areas (Andrade & Rhodes, 2012). However, this has not always been replicated in the fisheries context (Hatcher & Gordon, 2005). More recently, Arias et al. (2015) found that only higher levels of stakeholder involvement in management decision-making were positively associated with compliance, suggesting that superficial involvement such as attending meetings but not participating in them is insufficient.

The representation of fishers in regulatory decision-making has also been linked with transparent and effective communication of decisions by fishery authorities, which serves to improve the perceived legitimacy of the authority, and in turn, improve compliance (Bose & Crees-Morris, 2009). A disrespectful attitude of fishers toward regulations has been attributed to fishers having no faith in the science underpinning management decisions as well as loose enforcement by fishery authorities (Damalas & Vassilopoulou, 2013; Young, 1998). This also relates to the suggestion by one author that the immediate and notable presence of authority itself serves to legitimise it (Gezelius, 2007), and the more accepted view that noncompliance arises, in part, due to concerns about the legitimacy of the fishery authority (Dresdner et al., 2015; Nunan et al., 2018; Parés et al., 2015). However, one study found that situational variables such as stock abundance and income potential were more strongly associated with compliance behaviour than perceived legitimacy of compliance officers (Kuperan & Sutinen, 1998). Interestingly, in a qualitative study of three groups of fishers in Scandinavia, Gezelius (2007) found that legislator's perceived authority alone was insufficient to generate strong reasons for compliance, while a combination of legislators' perceived authority and the perception that the law is formally enforced was sufficient. Moreover, even where a legislator was perceived to lack authority, a significant risk of detection and penalty alone was sufficient to generate strong reasons for compliance (Gezelius, 2007). Bound up in the notion of legitimacy is fairness: perceived fairness of regulations and perceived fairness of access to fish. Arias et al. (2015) found that fishers who reported seeing other fishers engage in illegal fishing activities had significantly lower self-reported levels of compliance. The authors suggested that if fishers perceive an unfairness in the amount of fish other fishers are catching, they are less likely to comply themselves (Arias et al., 2015).

An example of a normative measure involves encouraging fishers to provide information on the noncompliance of other fishers (with or without reward). The advantage of this approach is that it lowers the cost of enforcement for fishery authorities. In recreational fisheries in some US states, signs are used to list open and closed seasons and encourage people to contact a hotline number if they witness noncompliant fishing activities (Anderson, 1989). When there is a sufficient proportion of fishers that support and comply with the regulations, social pressure has been deemed an effective means of improving compliance outcomes (Bose & Crees-Morris, 2009). However, in a study where 40% of fishers perceived that many or most other fishers landed over-quota fish, 90% believed that if they were to land over-quota fish this would not change

other fisher's opinions of them (Hatcher & Gordon, 2005). Another normative measure that has proven to be effective involves public shaming of imposed sanctions as an educational tool to deter other fishers from engaging in noncompliance (Crawford et al., 2004). For example, publishing print material and hosting seminars on cases of violations have been suggested as measures to combat high rates of noncompliance in fisheries; these might include information on statistics of sanctions imposed by fishery authorities and convictions delivered (Catedrilla et al., 2012). However, public shaming has been considered ineffective in some jurisdictions where the financial benefits of breaching regulations are substantial (Clarke & Jupiter, 2010). Education programs with the aim of increasing awareness about the sustainability objectives of the fishery and its linkages with compliance strategies, as well as promoting social responsibility for fish stock sustainability have also been proposed as effective normative compliance strategies (Cooke et al., 2013; Karr et al., 2017; Slater et al., 2014).

Empirical analysis of noncompliance: Situational crime prevention

To some extent, the situational crime prevention approach is a blending of the rationalist and normative perspectives on compliance: three of the five crime reduction strategies (reducing rewards, increasing risks, increasing effort) operate on the situational opportunities dependent on rationalist decision making, while the remaining two (remove excuses, reduce provocations) encapsulate emotional and psychological variables implicit in the normative perspective. Although a relatively new approach in the fishery context, it has been recognised that many fisheries unknowingly already employ measures grounded in situational crime prevention theory. For example, Petrossian (2015) notes that licences have been used to 'control access to facilities', and port inspections have been used to 'screen exits', under the 'increase the effort' strategy of situational crime prevention, while vessel monitoring has been used to 'reduce anonymity', and observer programs have been implemented to 'utilise place managers', under the 'increase the risk' situational crime prevention strategy. Other examples are increasing mesh sizes of nets and making use of square meshed netting to reduce the catch of undersized fish (Anderson, 1989; Damalas & Vassilopoulou, 2013) which would serve as 'control tools' under 'increase the effort' and 'assist compliance' under 'remove excuses', as well as implementing a night-time curfew for fishing (Department of Primary Industries and Regional Development, 2018) as a means of 'assisting natural surveillance' to 'increase the risk'. In the wildlife conservation literature more broadly, the proven efficacy of patrol effort in reducing noncompliance can be attributed to 'strengthening formal surveillance' to 'increase the risk' for offenders; the use of a program in which participants are recompensed for carrying out conservation-related activities at the local level 'extends guardianship' and 'assists compliance' with regulations; community-based programs educate locals on sustainability objectives and set rules to 'remove excuses'; and intelligence-led policing and hot spot policing combined with a measure of competing against other protected area teams on patrol success metrics has led to more motivated officers and greater patrol performance (see Kurland et al., 2017).

An important implication of rational choice theory that is recognised in situational crime prevention is the notion that the spatial and temporal location of fishers engaging in noncompliant activities is not random but based on the situational opportunities available to the offender. The notion that resources should be employed at times and places where the motivation for illegal fishing is particularly strong is not new (Anderson, 1989; Arias et al., 2016; Damalas & Vassilopoulou, 2013). For example, Arias et al. (2016) concluded that monthly trends and the lunar cycle can inform patrolling practices, and by focussing deterrence on times and places where it is most impactful, costs to management in terms of money and effort can be reduced. Not dissimilarly, in relation to areas with high proportions of juveniles of fish species, it has been suggested that spatiotemporal closures in predictable hotspots might be an effective managerial tool to ensure sustainability (Damalas & Vassilopoulou, 2013) given their success in effectively reducing unwanted catches (Dunn et al., 2011; Gilman, 2011; Poos et al., 2010).

More recently however, this has been explored through a situational crime prevention lens. Weekers et al. (2019) found that fishing poachers tend to offend at targets closer to their residential locations than further

away, which is consistent with routine activity theory and an offender's awareness space (Cohen & Felson, 1979). Furthermore, vulnerable areas for poaching tend to be those nearest to common access points, suggesting that enforcement efforts should target these hot spots (Weekers et al., 2019). One suggested measure to increase the risk to offenders in these hot spots includes extending informal guardianship through tourism operators or other fishers (Weekers et al., 2019). Indeed, higher tourism levels have been positively associated with greater levels of compliance (Arias et al., 2015). However, tourism facilities have also been found to act as crime generators, or places where illegal fishing co-occurs alongside legitimate activities; as such, it has been recommended that managers increase the risk to offenders by extending guardianship in these hot spot locations (Weekers & Zahnow, 2019). Strengthening formal surveillance by increasing patrol efforts and using new technology such as unmanned drones have also been suggested, as well as micro-targeted media campaigns addressing noncompliance to specific groups of people based on their residential proximity to hot spots, micro-targeted education such as the installation of roadside displays, and engaging with recreational fishers near hot spots prior to accessing the fishery, serving to remove excuses for noncompliance (Weekers & Zahnow, 2019; Weekers et al., 2019). Additionally, in relation to the illegal fishing of crab species, 'educating consumers' and 'safeguarding the most exposed species' through 'extending guardianship' have been suggested as crime prevention measures (Petrossian et al., 2015; Petrossian & Clarke, 2014). Although the regulatory measures of minimum legal size, prohibiting capture of egg-carrying female crabs, having closed seasons and using individual fishing quotas to limit catches are proposed as ways of safeguarding the most exposed species, it is highlighted that enforcement needs to be increased such that fishers perceive that apprehension is a likely consequence of noncompliance (Petrossian et al., 2015).

Conclusion

The literature overview began by highlighting the significant Blue Swimmer Crab recreational fishing culture in Western Australia and South Australia. Some of the noncompliance issues faced by each jurisdiction were presented, as well as the rules, underlying legislation, and compliance strategies currently in operation. Both the WA and SA Blue Swimmer Crab fisheries have regulations on minimum size, bag limits, boat limits, closed seasons, protection of egg-carrying females, and gear restrictions, among others. The primary objective of both jurisdictions in their compliance programs is to encourage cooperative compliance. This is predominantly targeted with education and awareness measures such as running seminars and providing a range of educative materials in a variety of languages. Coupled with this is an enforcement strategy including patrols, catch inspections, surveillance, imposing sanctions and creating general deterrence with targeted media coverage.

In the second part of the literature overview, evidence for commercial and recreational fisheries compliance strategies relating to the overarching rationalist, normative, and situational crime prevention perspectives was presented. In short, the rationalist literature argues for increasing the probability of detection and more severe sanctions so as to nullify the expected reward and effort in engaging in noncompliant fishing activities. A number of compliance strategies have been proposed to address this, including: training officers in the process of prosecution, ensuring strict implementation of the standard operating procedures of apprehension by compliance officers; regular patrolling by officers, providing officers with cameras and video equipment to document evidence during operations, ensuring officers are more vigilant, increased quality and thoroughness of inspections, focussing scarce monitoring resources on individuals identified as more inclined to noncompliance, and a calculated patrol strategy based on spatial and temporal frequency of violations. As well as introducing large penalties for regulation violations, graduated sanctions and loss of privileges have also been proposed as effective sanction measures.

The normative perspective provides evidence for facilitating stakeholder participation in decision making and design of management rules and processes, particularly where there are high levels of stakeholder participation rather than superficial engagement. Transparent and effective communication of decisions by the fishery authority is also supported as a means of enhancing the perceived legitimacy of the authority to

fishers. Social pressure through fishers being encouraged and supported to report noncompliance, public shaming of imposed sanctions through published print material and seminars on cases of violations, and education programs to increase awareness about the sustainability objectives of the fishery and its linkages with compliance strategies as well as encouraging social responsibility for fish stock sustainability, have all been proposed as effective compliance strategies.

Finally, the situational crime prevention approach presents a number of control mechanisms that can be employed in the fisheries context to reduce crime, these include: licences to control access, port inspections to screen exits, vessel monitoring to reduce anonymity, observer programs to utilise place managers, increasing mesh sizes to control tools and assist compliance, implementing a night time curfew to assist natural surveillance, increasing patrol efforts and using new technology such as unmanned drones to strengthen formal surveillance, the use of a program where participants are compensated for carrying out conservation-related activities to extend guardianship and assist compliance, community-based programs to educated locals on sustainability objectives to remove excuses, micro-targeted media campaigns addressing noncompliance to specific groups of people based on their residential proximity to hot spots, micro-targeted education such as the installation of roadside displays, and engaging with recreational fishers near hot spots prior to accessing the fishery, serving to remove excuses for noncompliance. Crucially, where regulatory measures such as minimum legal size, prohibiting capture of egg-carrying female crabs, having closed seasons and using individual fishing quotas to limit catches are in operation, it is highlighted that deterrence needs to be enhanced such that fishers perceive apprehension as a likely consequence of noncompliance.

Stage 2: Brief summary operational noncompliance datasets

While both regulatory agencies, DPIRD for WA and PIRSA for SA have been collecting data relating to the fishery since at least 2009, trend analysis has not occurred independently. As such, there exists a suite of data that provides insight into noncompliers participating within each fishery. This information can be useful to understand noncompliance trends and therefore contribute to minimise cost to the regulators by refining enforcement targeting activities and maximise effectiveness of education campaigns. While operational staff understand the fishery, analyses confirm and establish an evidence base on which resource- and sustainability-focused decision-making can be made with confidence.

The WA and SA regulators, DPIRD and PIRSA respectively, collect compliance data as part of their operational business. Incidents of noncompliance are recorded by patrolling officers in realtime into data management system(s) called Electronic Patrol Reports and eBrief in WA and Fisheries and Aquaculture Collection Tool (FACT) and eBrief in SA.
Each jurisdiction's data holding dates prior to the period analyzed (2009 through 2019), however for reasons of completeness and reliability, data collected prior to 2009 was excluded. Deidentified extracted data was cleansed prior to handover for analysis. The process of analysis underwent the following activities: data collation, generating logic formulas to produce time series results output aggregated at the monthly and annual level, conducting basic descriptive analyses, and producing time series graphical output to visualize emergent trends.

Data collation involved organizing the datasets such that they were comparable across jurisdictions and suitable for conducting descriptive analyses with. For example, the age of offenders in the WA dataset was converted from age in days to age in years. Similarly, offence date and time variables were separated and converted into the appropriate data type. Data collation also involved producing additional columns that captured the output of logical arguments spanning multiple existing data columns. Logic formulas were then written and executed to produce time series output for descriptive analysis. For example, a logic formula commonly used was 'COUNTIFS', to calculate the number of unique offences when multiple arguments were satisfied, including aggregating offences at the monthly and annual level.

The time series results output was captured in separate data tables for each analysis, which enabled simple descriptive analyses such as totals, proportions, averages, and standard deviations to be calculated. Time series figures were then produced from the results output for visual inspection of emergent trends. Microsoft Excel was used in each of these tasks due to the simplicity of the descriptive analyses conducted and the visual interface of this software aiding instantaneous and ongoing verification of the results output.

Full quantitative results are available in Appendix B, but to provide a broad understanding of the noncompliance landscape, a snapshot review of comparative noncompliance incident data are provided. During the 11 years between 2009 and 2019, WA recorded 6,462 incidents of noncompliance relating to the Peel-Harvey Blue Swimmer Crab fishery, while SA recorded 2,884 incidents of noncompliance across the same period for the Blue Swimmer Crab fishery. Figure 1 shows a breakdown by year for WA and SA. While overall, WA recorded more than double the SA incidents during the same period, in 2017 SA peaked higher than WA, after a dramatic dip in WA incidents of noncompliance since 2014. By 2019, incidents recorded by both jurisdictions were somewhat similar. In SA, the steady rise in noncompliance is consistent with the increased focus to target compliance in the fishery. SA instances again dropped in 2018 but rose slightly in 2019. Similarly, since 2017, WA recorded a steady increase of instances of noncompliance. In 2019, WA recorded only a slightly higher number of noncompliance compared to SA. WA's introduction of a $1,000 maximum infringement in July 2013 may have played a role in driving down the noncompliance rate in Figure 1, and the education and enforcement policy changes may also be relevant.

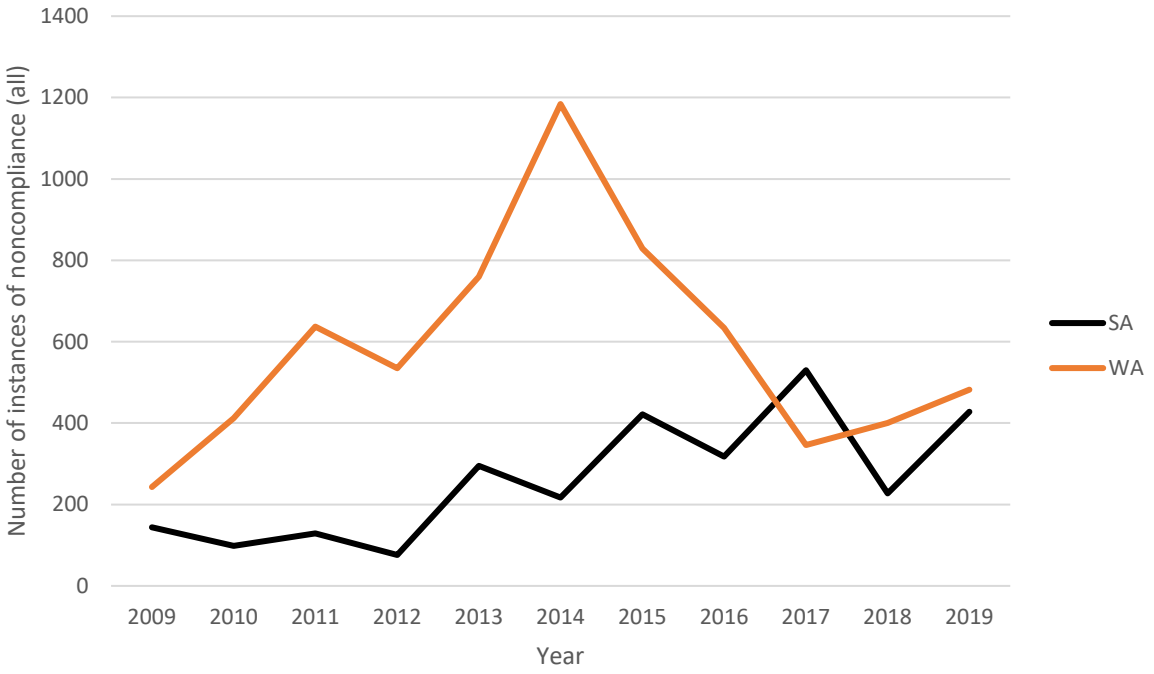


Figure 1. Number of instances of noncompliance (all) in Western Australia and South Australia (2009-19)

Figure 2 shows the noncompliance age cohorts for WA and SA Blue Swimmer Crab fishers. In instances where demographic data for fishers is not readily available, the age-range of noncompliers can usefully assist regulators to describe and target potential noncompliance among fishers while patrolling. However, recreational fishers often fish in groups and this metric relates to only those identified as noncompliers within the group, rather than all participating fishers, whether compliant or not. It is plausible that age trends identified among noncompliers are not dissimilar to that of the general fishing population, without reliable demographic data of these specific fisher populations it is not possible to make further inferences about the representativeness of this demographic data.

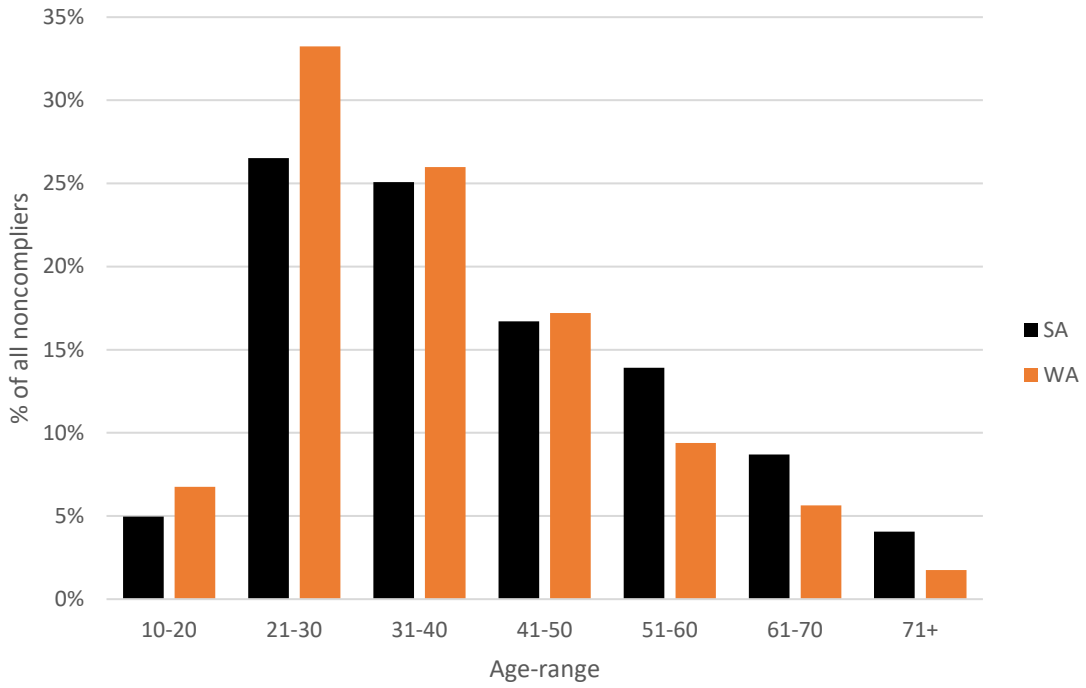


Figure 2. Percentage of instances of noncompliance (all) between 2009 and 2019 in Western Australia and South Australia by age-range of noncompliers

In WA and SA, noncompliers tend to be younger; in WA, two-thirds (n=4,441, 66%) of noncompliers intercepted below 40 years of age and SA recorded similar results for the same age cohort (n=1,780, 57%). WA recorded a marginally higher number of noncompliers in the 21-30 year age-range compared to SA (33% and 27%, respectively), while SA only exceeded WA noncompliers among the older cohorts (over 51 years) (combined totals 27% and 17%, respectively). Successful recreational participation in this fishery requires little gear and experience and is not physically demanding, lending itself to wide participant engagement.

A useful learning from Figure 2 may potentially inform the methods of educational communication about the fishery. Specifically, WA regulators may opt to disseminate educational messages about this fishery via its various social media platforms given the much higher cohort of younger noncompliers and acknowledging that preferred social media platforms differ by age group. Whereas, given that a higher number of older, noncompliant participants exist in SA, in addition to educational communication via social media, forms of communication more familiar to older populations such as in-store brochures, mail out and/or email may be more effective.

Gender is another potential identifier to understand noncompliance. Overwhelmingly in both WA and SA, males were over-represented in the data.

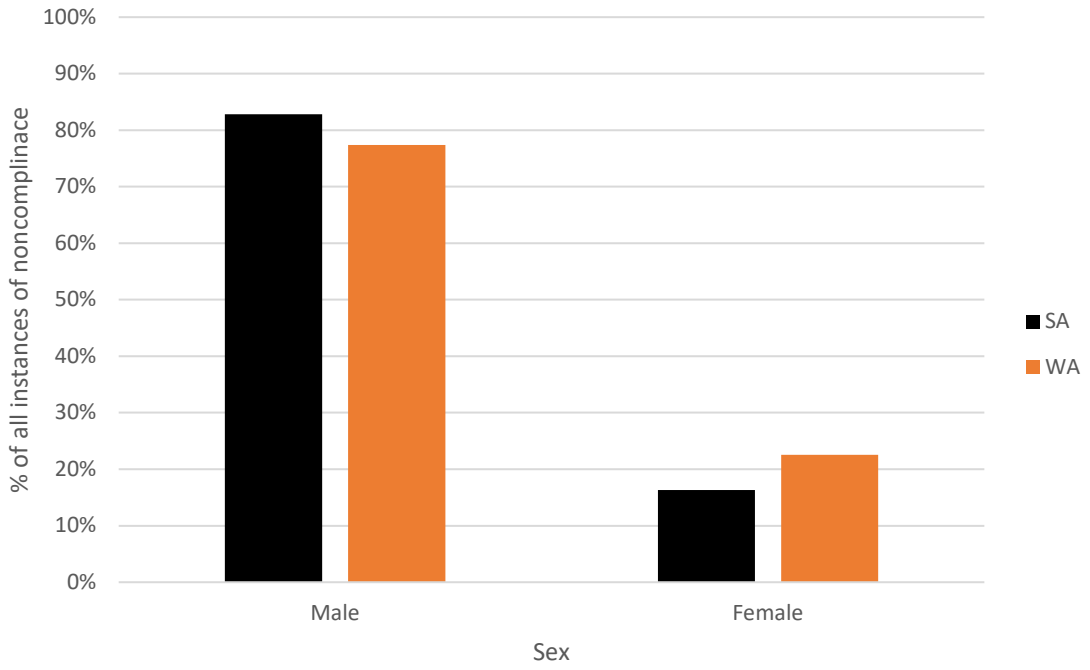


Figure 3. Percentage of instances of noncompliance (all) between 2009 and 2020 in Western Australia and South Australia by males and females

In WA, males represented 77 percent (n=5,208) of incidents of noncompliance between 2009 and 2019. Females in WA were attributed to 23 percent (n=1,516) of incidents of noncompliance. Meanwhile in SA over the same time period, the breakdown of noncompliance incidents were even more likely to be attributed to males (n=2,606, 83%) compared to females (n=514, 16%) and 27 incidents (1%) failed to record the gender of the noncomplier.

Figure 4 breaks down the instances of noncompliance by month, aggregating across the 11 years between 2009 and 2019.

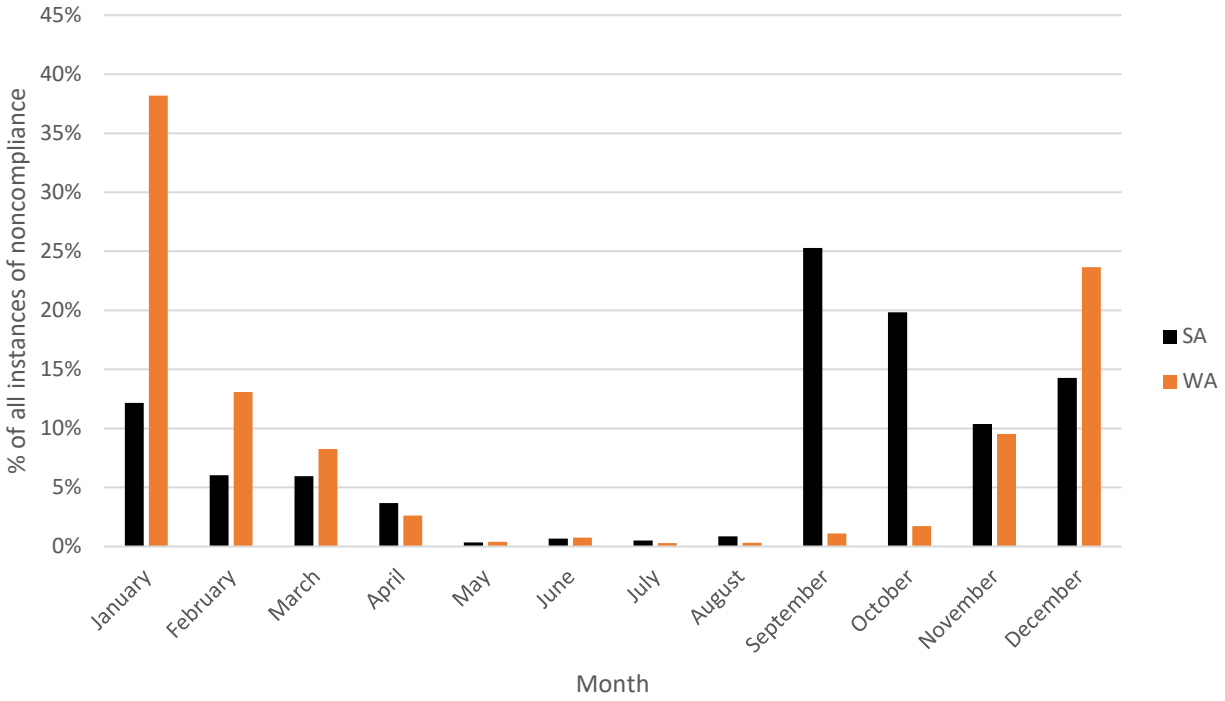


Figure 4. Percentage of instances of noncompliance (all) between 2009 and 2019 in Western Australia and South Australia by month

As a major recreational catch method for this fishery involves shore-based wading and a need to see crabs, it is understandable that greater numbers of fishers would engage in this fishery over the spring and summertime months (September through February), whether legally or illegally. Overall, in SA the months of greatest noncompliance are September through January, with the data indicating that September had the highest number of offences (n=729), whereas in WA, during November through March the amount of detected illegal activity is highest, peaking in January (n=2,468). In the cooler months with more rainfall (May to August), fewer fishers are intercepted due to limited crab availability as crabs 'tend to move from estuaries into nearby marine waters during winter' (Department of Primary Industries and Regional Development, 2021). However, in WA, there are often undersize crabs early in the season (late spring) as they have yet to moult into their new, larger shell. There is therefore a high chance of catching undersize crabs during November and December.

Conversely, in both WA and SA, there is a dramatic decrease in the number of detected offences during May through August. This is likely due to several reasons: fewer interceptions of noncompliance as the number of patrols hours are lower (the 2018 and 2019 WA average May through August=323 hours, compared to 671 hours September through April; the 2018 and 2019 SA average May through August=28.5 hours, compared to 178 hours September through April); weather conditions are poorer and the general availability and size of crabs are lower, proving less desirable, and so fewer people participate in the fishery. The WA fishery is generally closed from September through November to protect juvenile crabs and decrease the need for a large enforcement presence to check crab catches. In the southern Australian region where both these fisheries are located, in May through August, the daylight hours are shortest and are more likely to be cool, wet and windy and as such fisher effort (see catch method above) decreases. Crabs typically mate in autumn, and egg-carrying females are not allowed to be taken, further reducing the participation in the fishery over winter.

Figure 5 provides a day of the week snapshot of noncompliance.

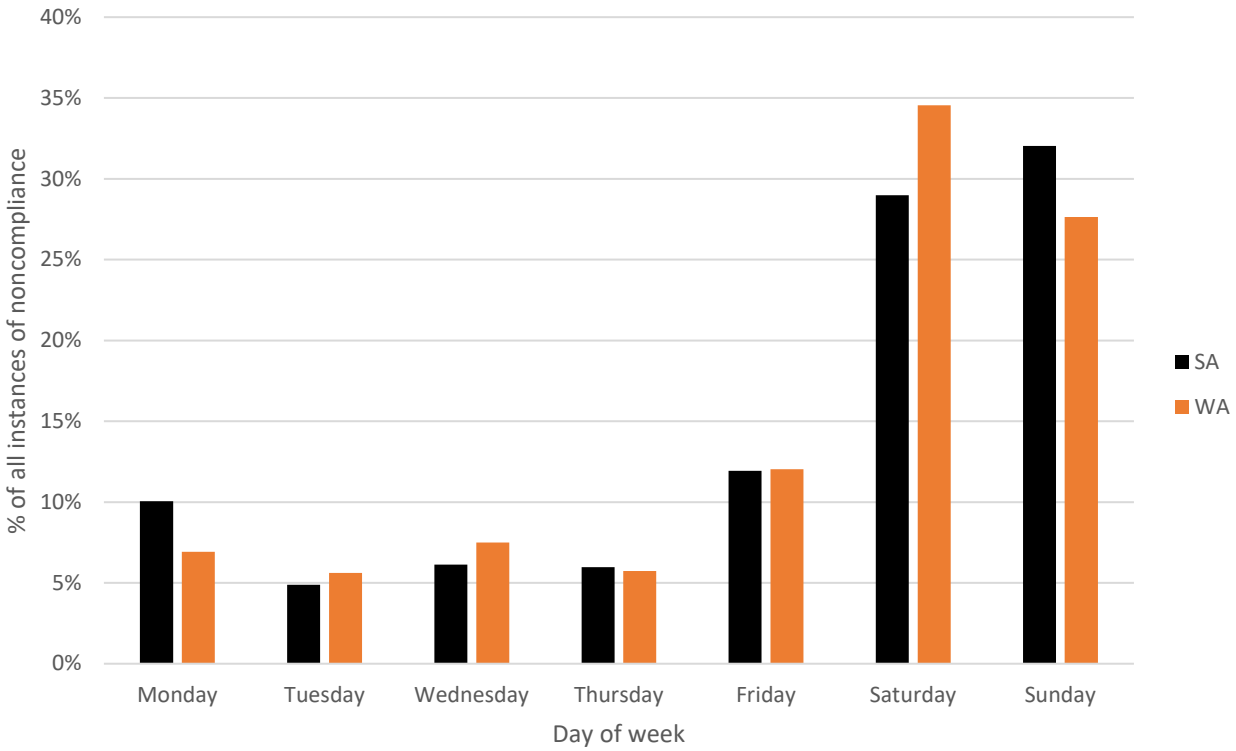


Figure 5. Percentage of instances of noncompliance (all) between 2009 and 2019 in Western Australia and South Australia by day of the week

This research considers only the recreational participants that were inspected in the Blue Swimmer Crab fishery. It is little surprise that the greatest recreational (noncompliance) activity occurs across the weekend days in both jurisdictions when working-age adults are less likely to be at work. In both WA and SA, detected offences are more than double on Saturday and Sunday than weekdays, typical of the workweek. Friday noncompliance increases, indicating that there is more than likely greater participation in the early evening (see Figure 6). In WA, crab fishing is a popular family pastime, leading to greater participation on Friday through Sunday. It is not possible to determine from our dataset whether we are seeing increased illegal activity, or simply higher fisher participation. Patrol effort also reflects these trends, focusing on weekends rather than weekdays.

Figure 6 shows the breakdown of noncompliance instances across 2009 and 2019, by timeslot for both WA and SA.

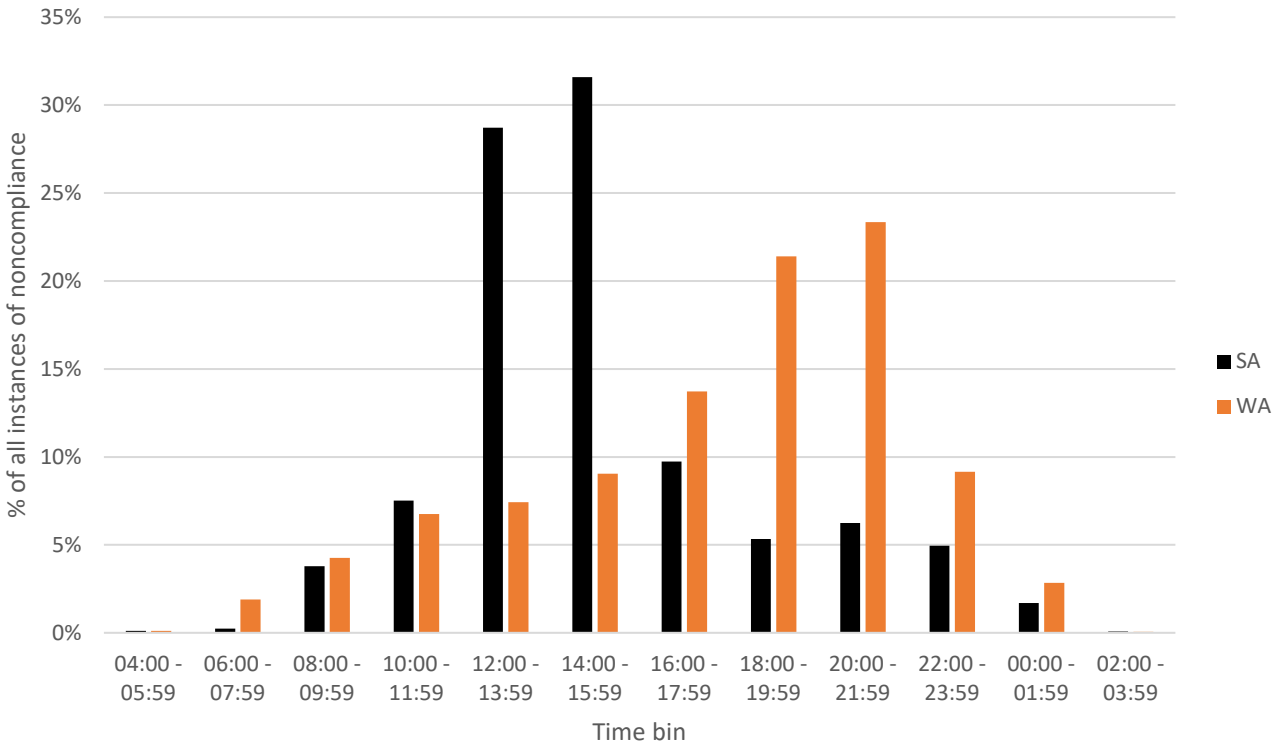


Figure 6. Percentage of instances of noncompliance (all) between 2009 and 2019 in Western Australia and South Australia by time of offence

Grouping all days of the week, Figure 6 shows noncompliance by time of day. The data show that in WA illegal activity is more commonly detected in early to later evening (16:00-22:00), whereas in SA, detected illegal activity corresponds to between midday and 14:00. This vast difference between the two jurisdictions can be explained by participation rates peaking over this period in each jurisdiction.

Few instances of noncompliance were identified overnight between midnight and 6:00, however this may align with decreased patrols during those times. However, patrolling regulatory officers are shift-workers in WA and so can be scheduled to patrol across all times of day based on perceived risk. In addition to patrolling officers, other forms of notification may result in instances of recorded noncompliance, such as public reporting via *FishWatch* or as detected and reported by other government officials operating in the area.

Figure 7 shows noncompliance activity against patrol hours. These data show the general correlation between detected offences and patrol effort.

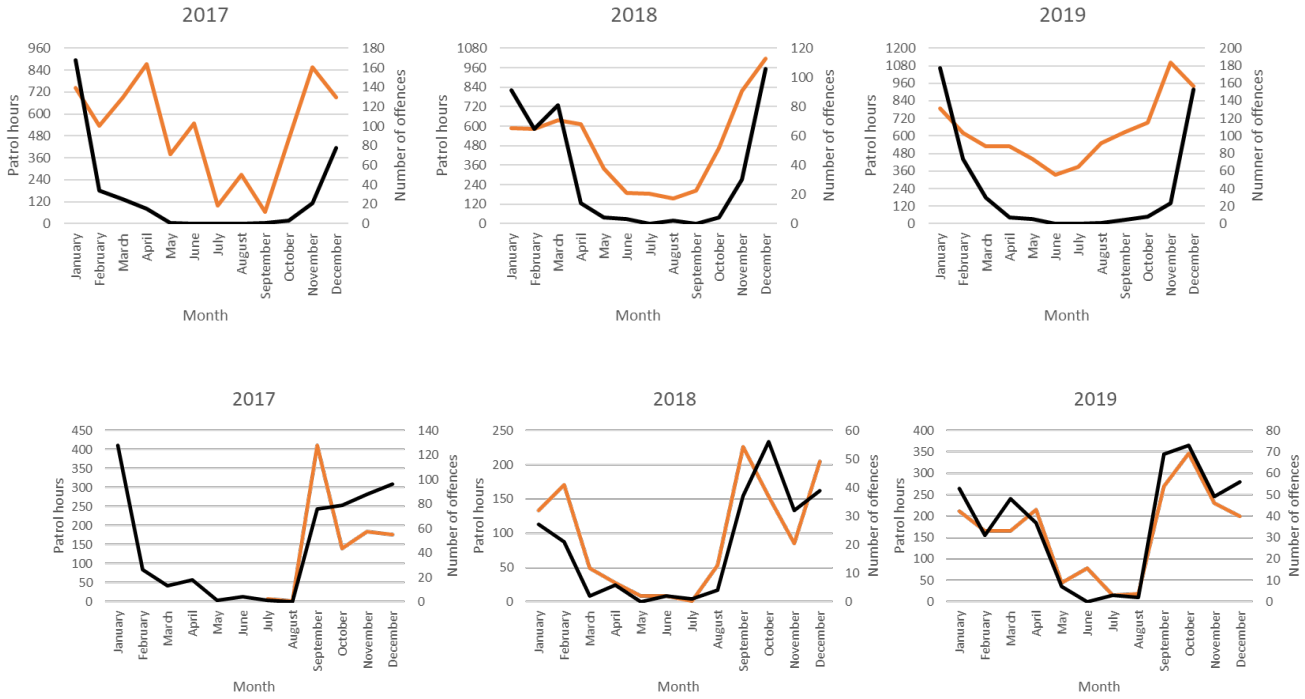


Figure 7. Number of all instances of noncompliance (black) and patrol hours (orange) per month in Western Australia (upper panel) and South Australia (lower panel) for the years 2017, 2018, and 2019

Across both WA and SA, as expected there is a correlation between increased patrolling hours and noncompliance intercepted. The WA patrolling strategy appears to have adjusted slightly between the three years. In 2018, the hours of patrol totalled 5,788, increasing in 2019 to 7,543 hours spread across the year. Despite the change in hours of patrol, the rate of offences intercepted varied little (2018 n=400; 2019 n=482). The patrol effort to noncompliance incidents intercepted averaged at six percent across both years.

This differs in SA. In SA, patrol data was not collected prior to July 2017. In 2018, 1,124 patrol hours were conducted increasing to 1,960 hours in 2019. While the hours of SA patrol were much lower than in WA, the patrol effort to noncompliance incidents intercepted averaged at 21 percent across the two years. This strategy of lower patrol coverage appears to lead to greater rates of noncompliance interception compared to hours of patrol.

It should be noted that both regulators are resource-limited and so all observed offence data is a subset of total noncompliance (i.e. including the noncompliance that occurs when enforcement staff are not present, noting that public reporting of illegal activity can mitigate this gap). When dealing with enforcement data, without independent data relating to participation in fishing activities, it is always possible that the enforcement may be biased towards periods of perceived peak illegal activity and towards stereotyped noncompliers. Or it could be possible that enforcement patterns are widely known among the recreational fishing community, resulting in under-representation of noncompliant activity in the enforcement activity, though still reliant on crab availability. Total illegal catch, and total amount of illegal activity are unknown and cannot be estimated without some idea of fisher participation or catch. We have taken the simple assumption that the data are representative of fishing activity and noncompliant activity in both fisheries. This assumption highlights the importance of complementary independent data from recreational fisher surveys.

Stage 3: Brief summary of online perceptions survey datasets

Although both DPIRD and PIRSA regularly conduct online and in person surveys on recreational fisheries, including the Blue Swimmer Crab fisheries, these surveys are rarely designed to elicit perceptions specifically focused on compliance strategies. For Stage 3 of this project, the focus centred on compliance, elements of the regulatory frameworks, barriers to fisher enjoyment, and to determine optimal education and enforcement strategies. Broad findings are provided in this section as to provide an overview of general perceptions. Survey results involving perceptions relating to strategies to optimise compliance are included in Stage 5, below. For further results, see Appendix C (WA only due to SA data limitations) (Lindley & Quinn, 2022).

A voluntary and anonymous exploratory online survey was developed on the survey platform, 'Qualtrics', to answer the five research questions.[9] Like other recent online surveys of this kind (for example, see Spencer et al., 2021), much of the survey was original and designed to capture the variables of interest for this study. Subject matter experts within the relevant government departments determined that the survey questionnaire adequately captured the data of interest. The surveys comprised 10 questions (with nine of the 10 questions containing multiple parts), and included open-ended questions, multiple choice questions, and rating scales.[10] Identical surveys were prepared for WA and SA and disseminated internally within DPIRD and PIRSA, among recreational fishing networks and stakeholder groups, via social media, and in WA, via the online newsletter, *Catch!*.

A total of 215 respondents completed the WA version of the online survey, of which two were subsequently excluded due to incoherent text entries throughout the survey (mashing the keyboard and single letter responses throughout). This resulted in a total of 213 respondents who completed the survey and were included in the analysis. In SA, 14 respondents completed the relevant online survey with analysable responses. The distinct difference in response numbers makes the jurisdictions unviable for reliable comparison, however interesting takeaways are possible.

By way of background into recreational effort within the fishery, in both jurisdictions, survey participants were asked the frequency of participation. Most commonly, respondents agreed they engage in the recreational Blue Swimmer Crab fishery up to 10 times per calendar year (WA median n=8; SA median n=10). In WA, seasonal closures for approximately three months annually prevent year-round legal engagement in the fishery, whereas the SA Blue Swimmer Crab fishery is open year-round, which likely accounts for the higher median engagement in SA compared to WA. Survey results reveal that each trip, recreational shore-based fishers who responded to the survey are taking within the legal limit, in SA a median of 15 crabs (legal limit of 20 blue swimmer and sand crabs per person per day) and in WA a median of 10 crabs (legal limit of 10 blue swimmer per person per day).

The survey questioned why respondents may participate in the recreational shore-based Blue Swimmer Crab fishery. Respondents in both WA and SA convincingly identified 'food' as their main reason for participation, followed by 'enjoyment/outdoor activity'. In some instances, the motivation to fish for food may lead evasion of rules and increase the willingness to be caught, compared to those who are fishing purely for recreation. Linking noncompliance instances recorded by DPIRD and PIRSA could be correlated against other government-held data, for example police data to determine whether a link exists relating to the welfare of noncompliers fishing out of necessity. This further socioeconomic-related analysis was however, beyond the scope of this project.

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[9] Ethics approval was granted for the online survey on July 15, 2020, by the University of Western Australia Human Research Ethics Office (REF: RA/4/20/5978). The survey was active for completion from November 5, 2021, to December 17, 2021.

[10] See Appendix A for survey questions matrix.

Participants to the online surveys were asked their perceptions as to the current regulations. The majority of respondents agreed they are satisfied with the existing regulatory regimes in WA and SA, however, believe that rules are insufficiently enforced in both jurisdictions. Further, both surveys asked the frequency in which respondents commonly see other recreational fishers acting outside the rules. In WA, overwhelmingly respondents agreed that 'sometimes' they see people breaking the rules, while in SA respondents were equally split between 'sometimes' and 'most of the time', with 'always' the next commonly reported response, consistent with lower patrol effort compared to WA. The low response rate in SA prevents meaningful analysis of these perceptions, however it opens opportunities to optimise compliance in SA (see Stage 5, below). In both WA and SA, respondents chose 'never' as to frequency of reporting noncompliance. Strategies to enable greater formal reporting is explored in Stage 5.

The surveys sought respondents to estimate the rate of illegal fishing, based on their perceptions over the previous calendar year, against Objective 4. The survey questions failed to yield meaningful results for both WA and SA. Specifically, when prompted with questions to estimate the highest or lowest illegal take, respondents selected the highest or lowest options available, respectively, thus failing to show any discernible difference between possible estimated rates of illegal fishing (see Appendix A). These inconclusive results therefore further confirm that estimating illegal recreational Blue Swimmer Crab fishing is complex and alternate approaches to estimate must continue to be explored for these fisheries.

Data collected from an online public survey likely attracts a range of participants, including less targeted but also avid participants when compared to surveys conducted at popular fishing locations while fishing, and therefore these perception data may be less reliable. These data do, however, provide some insights into the perceptions of these populations which can be helpful in complementing other available data and literature.

Stage 4: Review of current approaches

The purpose of this project was to draw on official noncompliance and perceptions data to find gaps and opportunities to improve strategies and encourage compliant participation among recreational fishers, using the WA Peel-Harvey Blue Swimmer Crab fishery and the SA Blue Swimmer Crab fishery as case studies. Education and enforcement strategies exist to address noncompliance in both WA and SA. These existing strategies are reviewed against official noncompliance and perceptions data derived from Stages 2 and 3, linked to literature and relevant WA and SA regulations in Stage 1. Acknowledging that noncompliance data and survey respondent's perceptions represent a small sample of recreational crab fishers in each jurisdiction, the results therefore may not be truly reflective of all fisher behaviours, however useful interpretations can be derived.

Education

As noted in Stage 1, both WA and SA engage in educational campaigns to encourage compliance among participating fishers. Examples in WA include large multi-lingual temporary banners erected near popular fishing spots, permanent signage at beach access points and carparks, mobile illuminated trailer signs, dedicated educational outreach programs, social and digital media detailing the rules, for instance an app published by Recfishwest, and the DPIRD Fisheries website. While examples in SA include permanent signage at popular beach access points and carparks; illuminated messaging trailer signs strategically positioned in popular fishing locations; social and digital media including a recreational fishing app called *SA Fishing* and the PIRSA website with up-to-date fisher information; and Fisheries Officers and Fishcare Volunteers distribute crab measuring gauges and blue crab information brochures.

Additionally, both WA and SA have strategic communication plans discouraging noncompliance. WA uses media articles to promote sustainable fishing messages and seek to deter by publicly broadcasting newsworthy apprehensions and court outcomes. SA expands the messaging of court outcomes beyond

traditional media to include various social media platforms. Collectively, these measures seek to communicate with recreational fishers the regulatory rules governing the fishery and to promote compliance.

Enforcement

WA and SA have a comprehensive suite of regulations for recreational fisheries (see Table 1), including for their Blue Swimmer Crab fisheries. These regulatory regimes are effective in enabling noncompliance to be intercepted in both WA and SA (see Figures 1 and 7). The lack of licensing required for participation in these fisheries is what sets them apart from other fisheries, requiring greater analysis into whether the existing strategies are effective.

Reflecting on perceptions data from both WA and SA, overwhelmingly, survey participants are satisfied with the current rules and regulations governing Blue Swimmer Crab fisheries. Achieving a balance of satisfactory control is optimal to ensure participation continues sustainably. Indeed, survey participants indicated support for *harsher* compliance controls for recreational Blue Swimmer Crab fisheries; suggesting that should harsher controls be introduced, fisher enjoyment would be unaffected. In contrast, some literature noted in Stage 1 revealed that harsher penalties lead to an increase in noncompliance (see Stage 1). This is consistent with Furlong's (1991) findings. It is possible that the majority of recreational fisher participants are complying, meanwhile a low number of serious noncompliers are having a sizeable impact on the fishery. This is consistent with findings about serious noncompliers in quantitative datasets (see Appendix B, Results).

Achieving a balanced approach of fisher enjoyment and regulation is most desirable. If regulation is too lenient, the fishery may become unsustainable, and if too harsh, it can lead to disenchantment among participants who may then intentionally evade the rules or choose to spend their time and money on other activities, in other locations. While not within the fisheries space, some research in criminology that considers *the carrot and the stick* incentives for compliance, suggests that the 'carrot approach' appears to be more effective than the 'stick approach' (Geest & Dari-Mattiacci, 2013; Su & Cao, 2021). This research is confirmed by research from psychology that suggests most commonly people seek to avoid punishment (the stick), suggesting the incentives (the carrot) is more likely to be effective (Kubanek et al., 2015). Regulatory compliance strategies involving education and enforcement differ slightly between WA and SA though both achieve a balance in intercepting noncompliance (see Stage 2) and support for compliance strategies among the participating population (see Stage 3). Incentivising the fishing community to comply with regulations and indeed, reflecting on the literature (see for example Arias et al., 2015; Bose & Crees-Morris, 2009; Brick et al., 2012; Hønneland, 1999; Kuperan & Sutinen, 1998), cooperative compliance may be a sound opportunity to achieve this.

Stage 5: Strategies to optimise compliance

Against Objective 6 and drawing on results generated through this research project, we consider opportunities to optimise compliance through enhanced education and enforcement strategies for recreational Blue Swimmer Crab fishers in both WA and SA. These opportunities draw on criminological theory.

Deterrence theory

Deterrence theory seeks to prevent crime by increasing the costs-benefit calculation for (would be) offenders/noncompliers through high visibility of the potential punishment (Brisman & Carrabine, 2017; Keel, n.d.). As humans seek to avoid punishment, fisheries compliance strategies based on deterrence theory can be effective if they are tough and well communicated (Kubanek et al., 2015). For example, high monetary penalties handed down to recreational noncompliers in court, seeks to have a *specific* deterrence effect on that individual and reduce their potential for recidivism. Further, if the case outcomes with details of noncompliance (type and amount) and penalty is communicated to the public via regulator social media and by traditional media, it seeks to achieve *general* deterrence, shaming the individual and deterring the

public from copying the noncompliance, strategies commonly adopted by DPIRD and PIRSA. While not linked to fishing, research suggests public shame is a powerful tool in enhancing regulatory compliance (Braithwaite, 2018; Johnson, 2020; Kelley et al., 2009).

As compliance officers are unable to intercept all noncompliers, estimating the extent of illegal crabbing and confirming rates of recidivism is challenging and as such regulators would nonetheless be prudent to strategise the overall impact of a high number of minor noncompliers compared to a low number of serious noncompliers, as the aggregate could be equally as harmful. This may assist in determining the appropriate use of sanctions, such as individual fishing bans to achieve *specific* deterrence, or mandatory minimum sentences to achieve *general* deterrence.

Often, deterring noncompliant behaviour can be challenging, require legislative amendments, and increasing the level of regulator engagement required to be effective which may be considered an unsatisfactory use of public monies. These methods to control noncompliance may be unviable and therefore innovative approaches that encourage compliance are necessary. As such, looking to environment-focused prevention approaches may be more financially viable and sustainable longer term.

Situational crime prevention

Situational crime prevention focuses on the existing environment in which crime/noncompliance is high and finds opportunities to reduce that vulnerability. For example, as adopted by DPIRD and PIRSA (see Stage 1), using permanent and temporary signage to communicate relevant regulations such as daily limits, and size, and other restrictions at popular fishing locations. By analysing historical noncompliance trends (see Stage 2), may emerge to guide opportunities against situational crime prevention. Accepting that there will always exist people who are motivated to offend/noncomply (Clarke, 1997: p4), it is essential that regulators look to adopt measures that increase the difficulty and risks associated with noncompliance. While initial costs to implement measures to prevent noncompliance may be high, the ongoing benefit of situational crime prevention approaches is through reduced regulator engagement, though monitoring is essential. Drawing on the perceptions data from Stage 3 (see also Appendix A and C), participants were asked open text questions about compliance, some of which is included within the following approaches in Table 2.

Optimised approaches

Optimising compliance in the Blue Swimmer Crab fishery can be achieved in two overarching ways:

- Enforcement – administrative changes by the regulator to the fishery; and
- Education – targeting fishers to encourage altered behaviours when engaging in the fishery.

Reflecting on Stage 1, the situational crime prevention framework provides 25 techniques (see Table 2) within five broader crime reduction strategies of reducing rewards, increasing risks, increasing effort, removing excuses, and reducing provocations, which are seen to alter an offender's decision-making (Cornish & Clarke, 2003). Based on a situational crime prevention approach, Table 3 considers approaches in three of the broader crime reduction strategies. Excluded are 'reducing rewards', which would prevent fishing altogether, rather the aim is to increase compliance; and 'reducing provocations' which focuses squarely on the individual, beyond the scope of this research. As such, based on the remaining three broader crime reduction strategies, this research considers strategies to alter the landscape of the fishery to reduce opportunity for offending or noncompliance through target-hardening and outreach among the *majority* of participants is considered most viable, rather than seeking to alter the individual motivations and behaviours of the *minority* of participants. Drawing on literature, perceptions data and team expertise, the below matrix provides an overview of approaches that could be undertaken to limit noncompliance in these Blue Swimmer Crab fisheries.

Table 3: Matrix of potential education and enforcement approaches to enhance compliance in Western Australia and South Australia

MANAGEMENT TOOL	SITUATIONAL CRIME PREVENTION APPROACH	EXPLANATION
Enforcement		
Licensing shore-based recreational Blue Swimmer Crab fishers	**Increase the Effort; Increase the Risk; Removes Excuses**	A licence could be introduced with or without a fee. This would capture the fisher demographics so regulators have a better understanding of participation and can target educational activities accordingly. The Blue Swimmer Crab fisheries is likely to have high participation numbers. As such, it would be incumbent on inspectors to check licences for every participant and the potential to infringe those who do not have a licence. Obrego`n et. al (2020) in their WA study, also suggest introducing a shore-based licence for recreational Blue Swimmer Crab fishing. With a licence, regulators would communicate regulations and therefore remove excuses of misunderstanding rules for participation.
Tougher penalties	**Increase the Risk; Remove Excuses**	Widely communicating existing and increased penalties (if relevant) would contribute to deterring noncompliers. In WA when closed seasons are set for stock recovery, even harsher penalties could apply for those who are intercepted during closed seasons as participation during this 'outlier' period of time may be indicative of motivated illegal fishing.
Increased number of patrolling officers	**Increase the Effort; Increase the Risk**	The introduction of a fee-paying licence could support the funding of additional patrolling compliance officers. Increased visibility of compliance officers and therefore likelihood of catch inspection could address the concerns of survey participants as noted in Stage 3 and decrease the motivation to noncomply if the risk of interception increases. In additional to increased localised inspections, roadblocks at various chokepoints as fishers depart popular fishing locations could also target noncompliance.
Strategic patrolling	**Increase the Effort; Increase the Risk**	Drawing on the datasets presented in Stage 2, altering patrols to: • Randomise patrolling efforts, which will likely have greater potential to interrupt routine noncompliers knowingly operating outside patrolling timeslots. • Maintain patrols (albeit lesser time allocation) during low, shoulder and closed seasons. Consistent year-round patrols must complement education strategies to inform potential (noncompliant) participants during these periods as serious noncompliers are more likely to evade normal patrolling activity. • Operate plain clothed and uniformed patrols to ensure that compliance is encouraged regardless of fear of potential interception and punishment. • Introduce volunteer programs or honorary officers to bolster official patrolling officers.
Enhanced surveillance	**Increase the Effort; Increase the Risk**	Enhanced surveillance could be in the form of physical and natural surveillance strategies. Physical surveillance: • Increased patrols of fisheries officers on land at key entry points, air (including via drone), and on the water. • Installing lockable gates that are locked outside patrolled hours at viable entry points could limit vehicle entry and therefore with increased effort, may reduce potential for noncompliance. • Increased CCTV recording day and night around popular fishing areas and automate analysis of recordings making it less labour intensive. Capturing fishers at anomalous times may enable covert surveillance. Natural surveillance: • Increase paved footpaths and other amenities around fishing areas to increase foot traffic of general passers-by, dogwalkers and exercisers. • Ensure all fishing access points are well-lit at night to decrease opportunity for stealth activity without public visibility/interception. • Ensure shrubbery around fishing areas is maintained to enable ease of visibility by the public and officers alike.

Introducing (SA) and lengthening (WA) the seasonal closure period	**Increase the Risk**	Seasonal or temporal closures allows the stock to recover and increase in size, leading to greater fisher enjoyment. Those who fish during periods of temporal closure, particularly at night, indicate motivation to evade the rules. Randomised patrolling schedules at all popular fishing locations must continue during seasonal closures, to maximise visibility of patrols, although use can be made of electronic surveillance coupled with general deterrence strategies. This also increases the risk and outweighs benefit of illegally fishing during these times.
Ease of reporting	**Increase the Risk**	Perception data collected in Stage 3 revealed knowledge and awareness of noncompliance, however there was limited ability or willingness to report (possibly due to the preference to remain anonymous). Developing a safe, simple and fast reporting process is critical to encourage participation in 'cooperative compliance'.
Education		
Multilingual signage	**Remove excuses**	• Temporary and permanent signage is needed at popular fishing area with relevant information including regulations and penalties. Including a quick response (QR) code on the signage will allow participants to find further information in multiple languages. Providing overt information may reduce the motivation to noncomply, or internal justification of lack of awareness of the rules. • Periods of seasonal closure must be clearly signed, such as the use of large temporary banners.
Official communications	**Remove excuses**	Method: • Multigenerational fishing groups will likely receive information in differing ways. As such, it is important for regulators to ensure they communicate via varying avenues. In addition to traditional avenues of communication such as pamphlets/brochures at popular fishing locations and fishing supply stores for example, and email newsletters, regulators must also engage frequently via social media. Social media is used differently by different populations and posts must extend across several to maximise reach. Apps with notifications are also a popular means of communication, as has already been adopted in SA (SA Fishing App). Opt-in preferences (e.g. language and communication style) could be specified by fishers as part of a licence application process. • Thought could be given to the literacy levels of the target audience: with low levels of reading ability, icon/cartoon-based information may result in higher uptake of the messaging into the target group. Frequency: • Survey participants indicated they would welcome more rather than less communication. During the open and indeed peak season of Blue Swimmer Crab fishing, short weekly announcements may be suitable, as well as at season opening, mid-point and closing (WA only). During off-peak months and closures (WA only), continued engagement with the fishing participants is important to serve as a reminder of ongoing patrols and inspections. If licences are introduced for shore-based recreational Blue Swimmer Crab fishers, regulations should be provided when licences are taken out and renewed. Content: • To widen reach, available in multiple languages and icon/cartoon-based, the content of communication must include key regulation information such as daily take/bag limits and minimum size of crabs, since the analysis in Stage 1 confirms those the most common forms of noncompliance. Further information such as how to measure a crab, fishing techniques and how to enjoy your catch could be well received. Apps may also include information such as a measuring tool (e.g. using the camera), quick report for noncompliance and even weather and stock conditions for popular fishing areas. As is the case in SA, surveys and sustainable alternative fish are also welcome additions to better inform fishers.
Informal communications	**Remove excuses**	Social online forums exist to share information about fishing. Regulators and relevant recreational fisher bodies could engage informally with the fishing community by answering questions and providing advice, such as good fishing locations, as well as reminding fishers of the relevant rules.

Cooperative compliance

Against Objective 5, this project sought to test whether adopting cooperative compliance could be viable to enhance regulatory control over noncompliance of the two fisheries. Drawing on the key findings in Table 3, understanding how to optimise compliance by harnessing the relationship between the regulator and the recreational Blue Swimmer Crab fishing community warrants closer enquiry.

Cooperative compliance seeks to empower the fisher to want to comply. This can be achieved through enhancing education strategies. By enhancing the information communicated to include the *why*, may be more effective that just communicating the *what*. For example, in WA, the in 2015-16 the international standard-setting body, the Marine Stewardship Council (MSC) certified its first commercial and recreational fishery, the iconic WA Peel Harvey Blue Swimmer Crab fishery. Maintaining this as a sustainable recreational fishery is a high priority for DPIRD, however information about the certifier and what the certification means for the fishery, and beyond, may not be commonly known among the recreational Blue Swimmer Crab fishing community. Indeed, communicating with the recreational fishing community as to why the fishery may even require regulatory controls may be necessary to encourage compliance (McClanahan & Abunge, 2016). Without broad knowledge transfer to the community, there may be little incentive to comply or consumer buy-in to any boosted compliance efforts.

Understanding how fishers seek enjoyment from the fishery can also enhance compliance. In Stage 3, survey participants were asked what would reduce or impact on their enjoyment while fishing for Blue Swimmer Crabs. Resoundingly, the most common response was ‘low stock numbers’. It appears recreational Blue Swimmer Crab fishers accept that a sustainable approach to managing the fishery, which may include a tough stance on compliance, will lead to greater enjoyment through increased availability of crabs. Introducing (in SA) and extending (in WA) season closures, or limiting participation to weekends only, even as a one-year pilot to assist stock growth may be supported by the recreational fishing community. Previous perceptions research focused only on WA supports these compliance strategies (Obrego´n et al., 2020).

Cooperative compliance may be achieved through informal mechanisms to support formal patrols. Drawing on the perceptions data from Stage 3 (see also Appendix A and C), participants in both WA and SA regularly see other fishers noncomplying though rarely see compliance officers to intercept wrongdoers. While low respondents in SA prevent meaningful analyses of perceptions data, limited visibility of formal regulators may be supported by informal approaches, for example, this may include volunteers wearing either high visibility vests, or plain clothed who can capture footage and report to regulators. Some survey participants indicated reservations as to a shared/community compliance approach operationally, with concerns of the potential for vigilantism, inciting violence among fishers, and/or potentially cause a rift in the recreational fisher community. In which case, availability of anonymous hotlines to report noncompliance are more suitable and indeed, while extensive research supports shared informal/formal operational fisheries compliance (see for example Arias et al., 2015; Bose & Crees-Morris, 2009; Brick et al., 2012; Hønneland, 1999; Kuperan & Sutinen, 1998), it also suggests that regulatory control should remain within the remit of the regulator (Garza-Gil et al., 2015).

Rather than seeking community support for intercepting noncompliance, reporting incidents of noncompliance may be equally as effective, safer, and require less coordinated effort. Again, drawing on the surveys, in both WA and SA, many respondents chose ‘never’ as to frequency of reporting noncompliance. Developing strategies to enable simplified noncompliance reporting appears to be an opportunity for regulators. Methods such as visible QR codes, or in-app noncompliance reporting pathways with GPS enablers, as well as options to upload photo and/or video footage. This opportunity could also be effective and minimise the need to complete time consuming and detailed (online) forms, or relying solely on telephoning a hotline, which may be overheard by noncompliers and therefore unsafe. Ensuring that

regulators are providing opportunities for all generations of recreational fishers will assist in communicating a strong message of compliance intergenerationally within families and communities.

Caution must be taken as to the extent to which cooperative compliance may be utilised to prevent divisions within the fishing community. Sharing the responsibility through adopting cooperative compliance with the wider fishing community may bring about a willingness to comply and to report noncompliance. Garza-Gil et al. (2015) found that community fishers valued participation in regulatory development, as such compliance survey results can usefully guide education and enforcement directions. Embracing the recreational fishing community's views, though pilots, consultative feedback, and perceptions surveys are essential methods to ensure the balance between fisher enjoyment and compliance is met. This message must underpin a successful cooperative compliance strategy.

Conclusion

Balancing recreational fisher enjoyment while maintaining a well-managed fishery requires effective regulatory strategies to ensure biologically and economically sustainable fisheries. Drawing on a multidisciplinary approach, this project provides a better understanding of strategies to optimise compliance among recreational fishers, drawing on the two case studies, the Blue Swimmer Crab fisheries from WA and SA. The findings of this research can shape recreational fisheries education and enforcement strategies in these jurisdictions and fisheries, as well as others, applying the same methodology. By understanding the motivators and environment of these fisheries, implementing optimised compliance strategies is increasingly possible to ensure they are sustainable.

Implications

Against Objective 5, this project provided options to optimise compliance for recreational WA and SA shore-based Blue Swimmer Crab fisheries. The methodology combining quantitative and qualitative data can be conceptualised for any fishery or jurisdiction. Caution must be taken as to the quality of data collected and analysed as it may lead to skewed results. Further, it is acknowledged that the regulator-held datasets and survey data results represent a small sample of crab fishers and may not be truly reflective of all crab fisher behaviours and/or recreational fisher behaviour more broadly.

In Stage 5, this project revealed evidence-based strategies to optimise compliance and enhance cooperative compliance in recreational fisheries. It also confirms that drawing on criminology to inform compliance in fisheries management is a sensible approach.

Recommendations

Evidence-based, criminological theory-led approaches should be used to develop strategies for compliance in fisheries. This research shows that a multi-disciplinary approach to noncompliance, drawing on the strengths of varied and relevant disciplines can enable improved outcomes. Adopting reactive approaches without analysing the operational noncompliance datasets or seeking perceptions from the fishing community (including regulators, industry, stakeholders and recreational fishers) lacks a solid evidence-based understanding and cannot effectively achieve compliance.

Broadly, criminological theory proves useful in developing crime prevention strategies. This project shows that criminological theory is also useful in the development of strategies to understand and improve compliance in recreational fisheries, enhancing existing approaches to fisheries noncompliance. When pressure to sustain ocean resources is critical, it is necessary to look for opportunities to enhance compliance by more clearly understanding and strategising optimal approaches to fisheries compliance.

Further development

To confirm the usefulness of this methodology, testing against another fishery or jurisdiction would be a valuable development, adding to the results of this project. Evaluating implementations made drawing on this project would also provide insight as to the practical and operational usefulness.

Data quality is central to reliable analysis, therefore improving data collection must also be at the core of improved processes.

Extension and Adoption

Extension

This project methodology, whereby analysing official regulator longitudinal noncompliance data and perceptions of noncompliance within the unlicensed recreational Blue Swimmer Crab fisheries in two Australian jurisdictions, serves as a proof of concept that could potentially be extended across other fisheries and Australian states and territories. It sought to review the effectiveness of existing responses to compliance in WA and SA recreational Blue Swimmer Crab fisheries, from a multidisciplinary perspective. Building on this research framework, with little additional effort, a longitudinal study could review internal policy changes (including for example: patrolling strategies such as time of day/day of week; fisher targeting strategies; tolerance thresholds for imposing infringements compared to warnings); and impact of tide and lunar cycles on noncompliance and need to adjust patrol efforts accordingly, to determine what worked most effectively. Further, evaluating noncompliance trends instances against broader environmental changes would also need to be conducted to glean insight into the fishery for greater value-add. For example, fishing effort, reviewing the noncompliance instance data by year, married against knowledge of periods of low stock, impacts of weather, and other environmental impacts (such as COVID-19) to give a more holistic picture of the regulatory landscape.

This project methodology serves as a pilot to test the usefulness of analysing regulator-held noncompliance datasets alongside perceptions surveys to better understand motivations and behaviours around recreational Blue Swimmer Crab fishing in WA and SA. As this project showed, these data can then be analysed against criminological theory to use an evidence-based approach to guide more effective education and enforcement strategies. The project results show the value-add of criminology to proactively adopt education and enforcement measures, rather than following the traditional fisheries regulatory regimes that is typically reactive rather than proactive and therefore often lagging best practice.

Adoption Plan

Relevant WA and SA stakeholders including DPIRD, PIRSA, RecfishWest, and Recfish SA as well as the Australian Fisheries Management Forum (AFMF) and FRDC networks may benefit from the results of this research project to support policy, regulatory and compliance reforms elsewhere. This project's results can be immediately adopted by DPIRD and PIRSA and the methodology applied to fisheries elsewhere, including outside Australia. It is important to note that this was a pilot study and the impact of the project results, if implemented, would require a longitudinal evaluation to assess and is therefore beyond the scope of this project. Future research efforts would be greatly assisted by the availability of data relating to fisher effort and crab abundance as those are two important drivers of fishing activity and therefore any subsequent rates of noncompliance.

The MSC certified its first recreational fishery, the iconic WA Peel Harvey Blue Swimmer Crab fishery in 2016 and renewed recertification in December 2021. As such, maintaining this sustainable recreational fishery certification is a high priority for DPIRD. The 2021 recertification involves a five-year plan to meet MSC-set recommendations, which is currently underway. Specifically, mechanisms must be developed and implemented to monitor, control and surveil to prevent noncompliance. The results of this project are directly relevant and can be applied to meet the MSC's recommendations. DPIRD is responsible for ensuring the recommendations are met, and to assist established a Working Group combining an operational and expert team[11] to advise.

[11] Two team members of FRDC funded project 2019-011 are part of the MSC-recommended, DPIRD-led *Working group to address noncompliance in the Peel-Harvey Estuary*, Dr Jade Lindley (Working Group member - Expert advice) and Dr Timothy Green (Working Group Member – Operational advice).

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Project materials developed

See Appendix B and C.

Appendices

Appendix A: Survey matrix

Research question	Survey question
RQ1. What is the opportunity structure for Peel-Harvey/SA Blue Swimmer Crab fishers to engage in noncompliance?	Q1a. How many times a year would you go fishing for crabs in the Peel-Harvey area/SA (please respond as an average per calendar year – between January and December – regardless of fishery open/close seasons – as a whole number)? [open text field]
RQ1. What is the opportunity structure for Peel-Harvey/SA Blue Swimmer Crab fishers to engage in noncompliance?	Q1b. On average, how many Blue Swimmer Crabs would you catch per fishing trip to the Peel-Harvey Estuary/SA (as a whole number)? [open text field]
RQ1. What is the opportunity structure for Peel-Harvey/SA Blue Swimmer Crab fishers to engage in noncompliance?	Q1c. How often was your catch inspected on Peel-Harvey/SA Blue Swimmer Crab fishing trips? [Never – Sometimes – About half the time – Most of the time – Always]
RQ1. What is the opportunity structure for Peel-Harvey/SA Blue Swimmer Crab fishers to engage in noncompliance?	Q1d. How often have you seen fisheries inspections officers patrolling while you have been fishing for Peel-Harvey/SA Blue Swimmer Crabs (whether or not you have been stopped by the officers)? [Never – Sometimes – About half the time – Most of the time – Always]
RQ2. What are the perceptions among fishers of the current rules and regulations governing the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q2a. What do you think about the existing Peel-Harvey/SA Blue Swimmer Crab fishery rules and regulations? Please provide as much detail as possible (e.g., are the rules and regulations fair; restrictive; harsh penalties; lenient) [open text field]
RQ2. What are the perceptions among fishers of the current rules and regulations governing the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q2b. Do you think these views are commonly held amongst other fishers or do you think there are particular groups who may feel differently to your views/the views of your organisation on the rules and regulations regarding the Peel-Harvey/SA Blue Swimmer Crab fishery? Please provide as much detail as possible. [open text field]
RQ2. What are the perceptions among fishers of the current rules and regulations governing the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q3a. Is there anything that reduces or impacts your enjoyment when fishing for Blue Swimmer Crabs in the Peel-Harvey Estuary/SA? Consider, for example, season timeframe, stock numbers, personal safety, use of gear and equipment. Please provide as much detail as possible. [open text field]

RQ2. What are the perceptions among fishers of the current rules and regulations governing the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q3b. Do you think there are particular groups who may feel differently to your views about the things that may reduce enjoyment when fishing for Blue Swimmer Crabs in the Peel-Harvey Estuary/SA? Please provide as much detail as possible. [open text field]
N/A	[info block] Given that a licence is not required for the Peel-Harvey/SA Blue Swimmer Crab fishery, education campaigns need to be effective to make sure that fishers understand their responsibilities and do not take undersize crabs, berried female crabs, or more crabs than their bag limit. Fishers who do not follow the rules are *noncompliant*. The WA Department of Primary Industries and Regional Development (DPIRD)/ SA Department of Primary Industries and Regions (PIRSA) undertakes various educational campaigns to encourage willing compliance. For the purpose of this study, *noncompliance* is defined as a failure to follow lawful orders that may amount to a crime (Engel et al., 2012; Nix et al., 2019).
N/A	[info block] What do you think are the best ways to help fishers understand the rules and regulations in the Peel-Harvey/SA Blue Swimmer Crab fishery and to make sure that the rules aren't broken? Please consider:
RQ3. How can education be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q4a. Method: How should information about crab fishing be shared with fishers? [open text field]
RQ3. How can education be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q4b. Target audience: Who needs to be educated about the crab fishing rules and regulations in the Peel-Harvey Estuary/SA? [open text field]
RQ3. How can education be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q4c. Timing: When is the best time to educate fishers (any specific days and times)? [open text field]
RQ3. How can education be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q4d. Frequency: How often should education programs be delivered? [open text field]
RQ3. How can education be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q4e. Do you have any other suggestions on how we could best educate fishers about crab fishing in the Peel-Harvey Estuary/SA? [open text field]
N/A	[info block] Inspectors cannot check every fisher's catch to make sure that they are fishing in the right season and have not exceeded the bag limit or taken crabs that are too small or berried. DPIRD needs to optimise inspections and enforcement to maximise

	their chance of identifying rule breakers while balancing the cost to the taxpayer. For the following questions, please consider how DPIRD can optimise its inspections and enforcement most effectively at the least cost to taxpayers.
N/A	[info block] What do you think is the best way to enforce the rules in the Peel-Harvey/SA Blue Swimmer Crab fishery? Please consider:
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q5a. How often should inspectors be active? [4 times a day – 3 times a day – 2 times a day – Once a day – Once every 2 days – Less than once every 2 days]
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab Blue Swimmer Crab fishery according to fishers?	Q5b. What are the best times to inspect fishers' catches? [Weekday morning – Weekday midday – Weekday afternoon – Weekday evening – Weekday night – Weekend morning – Weekend midday – Weekend afternoon – Weekend evening – Weekend night]
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q5c. Who is most likely to break the rules? e.g., by fishing outside of the season, exceeding their bag limit, or taking crabs that are too small or berried? [open text field]
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q5d. Do you have any other suggestions on how we could better enforce rules and regulations in the Peel-Harvey Estuary/SA? [open text field]
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q6a. Do you think that DPIRD should be the only organisation enforcing crab fishing rules in the Peel-Harvey Estuary/SA, or should other groups support DPIRD and help control or reduce noncompliance? These groups may include other state government agencies, local government rangers, the community, private security patrols, FishWatch reporting, or neighbourhood watch programs. Please provide as much detail as possible. [open text field]
N/A	[info block] *Shared regulation* implies that others beyond the traditional (or formal) regulators may engage in some kind of 'enforcement. This may include 'informal regulators' such as other recreational fishers, volunteer groups, and commercial fishers.
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q6b. In your view, what are the incentives to shared regulation in the Peel-Harvey/SA Blue Swimmer Crab fishery? [open text field]

RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q6c. What are your thoughts on incentivising shared regulation to improve compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery? [Strongly disagree – Disagree – Neither agree nor disagree – Agree – Strongly agree]
N/A	[info block] While the concept of shared regulation intends to be inclusive and positive for fishers engaged in the fishery, this may not always be the case.
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q6d. In your view, are there any barriers to shared regulation in the Peel-Harvey/SA Blue Swimmer Crab fishery? [Yes – No] Please explain why. [open text field]
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers? **RQ5.** What is the perceived extent of noncompliance in the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q7a. How often do you see fishers in the Peel-Harvey Estuary/SA who aren't following the rules (e.g., have taken too many crabs, have kept crabs that are too small or berried, or who are fishing outside of the crab fishing season)? [Never – Sometimes – About half the time – Most of the time – Always]
RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers? **RQ5.** What is the perceived extent of noncompliance in the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q7b. Have you ever reported crab fishers for breaking the rules within the Peel-Harvey Estuary/SA? (please limit this response to *formal reporting* such as FishWatch or Crime Stoppers rather than informal reporting on social media) [Never – Sometimes – About half the time – Most of the time – Always]
N/A	[info block] Given that a licence and registration are not required to participate, little is known about the fishers who engage in the Peel-Harvey/SA Blue Swimmer Crab fishery.
N/A	Q8a. Why do you go fishing for Blue Swimmer Crabs in the Peel-Harvey Estuary/SA? Please provide as much detail as possible. [open text field]
RQ5. What is the perceived extent of noncompliance in the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q8b. Do you think other people go crab fishing for the same reasons? [Yes – No] Please explain why. [open text field]
N/A	[info block] While enforcement is necessary to ensure the fishery remains sustainable, 'over-enforcing' the fishery may reduce the amount of people who go fishing for crab recreationally. This may be seen as a barrier to fishing, among others.

RQ4. How can enforcement be optimised to ensure compliance in the Peel-Harvey/SA Blue Swimmer Crab fishery according to fishers?	Q9. Thinking specifically about enforcement, in your view, are there any barriers that limit fishers from participating in the Peel-Harvey/SA Blue Swimmer Crab fishery? Please provide as much detail as possible. [open text field]
N/A	[info block] It is unclear what proportion of the total Peel-Harvey/SA Blue Swimmer Crab catch are caught 'illegally'. *Illegal* catch may include taking undersize crabs, berried female crabs, or more crabs than their bag limit. Out of every 1000 crabs taken from the Peel-Harvey/SA Blue Swimmer Crab fishery:
RQ5. What is the perceived extent of noncompliance in the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q10a. Over the last year (Jan-Dec), what is your best guess of the largest number taken illegally over the whole season? [rating scale 0 – 1000]
RQ5. What is the perceived extent of noncompliance in the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q10b. Over the last year (Jan-Dec), what is your best guess of the smallest number taken illegally over the whole season? [rating scale 0 – 1000]
RQ5. What is the perceived extent of noncompliance in the Peel-Harvey/SA Blue Swimmer Crab fishery?	Q10c. Over the last year (Jan-Dec), what is your best guess of the most likely number taken illegally over the whole season? [rating scale 0 – 1000]

Appendix B: Project write up of the quantitative results

Lindley J, Quinn L (2023) Compliance in recreational fisheries: Case study of two blue swimmer crab fisheries. PLoS ONE 18(1): e0279600. https://doi.org/10.1371/journal.pone.0279600

Appendix C: Project write up of qualitative results

Lindley J and Quinn L (2022) Perceptions of compliance in recreational fisheries: Case study of the Peel-Harvey blue swimmer crab fishery. Front. Conserv. Sci. 3:968518. http://doi.org/10.3389/fcosc.2022.968518