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Acknowledgements

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Fisher surveys were conducted with the approval of the Tasmanian Social Sciences Human Research Ethics Committee (Ref: H0017285 and H0017297).

Abbreviations

ABS	Australian Bureau of Statistics
CBA	Cost–benefit analysis
CPUE	Catch per unit effort
DPIPWE	Department of Primary Industries, Parks, Water and Environment
DCE	Discrete choice experiment
ECSRS	East coast stock rebuilding strategy
ECSRZ	East coast stock rebuilding zone
ITQ	Individual transferable quota
TAC	Total allowable catch
TACC	Total allowable commercial catch
TARC	Total allowable recreational catch

Executive Summary

Southern Rock Lobster (*Jasus edwardsii*) has a long history of commercial exploitation in Tasmania, supporting a major fishery with recent catches in the order of 1000 tonnes p.a. and a landed value of about $90 million. The species has long represented a traditional food source for the local Aboriginal population as well as being highly prized by the recreational sector, with about 20,000 fishers taking recreational rock lobster licences each year.

Concerns around declining rock lobster stocks in Tasmania were identified in the late 2000s and in 2011 east coast stocks were assessed to have hit historically low levels, attributed to a combination of several years of below average recruitment and heavy fishing pressure. In response, an East Coast Stock Rebuilding Strategy (ECSRS) was implemented in 2013 with a goal to rebuild east coast stocks to greater than 20% of unfished levels by 2023. A key element of this strategy is to limit the average annual total catch (recreational and commercial) off the east coast of Tasmania to no more than 200 tonnes. Under the strategy the commercial fishery is subjected to a catch cap which is monitored within the quota management system. A number of measures have been progressively implemented to constrain recreational catches, including reductions in bag and possession limits and the length of the fishing season. In 2016, it was determined that the East Coast Stock Rebuilding Zone (ECSRZ) catch limit be split 79% to commercial and 21% to recreational sectors, reflecting the historic proportion of commercial and recreational catches from within the rebuilding zone. This meant that the initial maximum catch allocation was split 158 tonnes to the commercial fishery and 42 tonnes to the recreational fishery. Although there have been several adjustments to the maximum catch allocation, the proportional split has remained unchanged.

Management of the recreational component of the fishery has proven difficult, with the allocated catch share exceeded in all but one season since the rebuilding strategy was implemented. This situation is likely to be further exacerbated as stocks rebuild; higher catch rates are expected to attract increased effort and overall catches for the sector. For the commercial sector, the catch cap acts as a competitive catch quota which, as catch rates improve, is likely to influence fleet dynamics as fishers ‘race’ to take the limited catch.

Objectives
Understanding relationships between fisher behaviour, their expectations/aspirations, responses to changes in stock status and to management intervention is critical when implementing effective management strategies. This project aims to inform on the practical challenges to achieving the stock rebuilding objective and provide options to assist managers and both fishing sectors in achieving the ecological, social and economic goals for the rock lobster fishery.

Specific objectives of this study include:
1. Determine the relationships between recreational fisher behaviour (effort and participation) and rock lobster catch rates and abundance.
2. Assess fisher attitudes and compliance behaviour to management scenarios designed to achieve the east coast stock rebuilding objective.
3. Model the effectiveness of alternative management scenarios in constraining recreational catches as stock rebuild.
4. Model the impact on fleet dynamics, including economic implications, of the expected shift to an "Olympic" or competitive quota.
5. Evaluate the costs and benefits of short- and long-term management options for the east coast rock lobster fishery.

Methodology
The project is comprised of four key components: (i) recreational and commercial fisher surveys to investigate attitudes and preferences for alternative management scenarios; (ii) synthesis of available

fishery data (commercial and recreational); (iii) modelling of fisher responses to stock rebuilding and consequences of alternative management scenarios; and (iv) expert-informed analysis of policy settings and scenarios.

Two complementary surveys of recreational fishers were undertaken; (i) a survey exploring aspects relevant to social and catch-related aspects of rock lobster fishing, support for management options intended to constrain recreational catches and opinions about non-compliance; and (ii) a discrete choice experiment (DCE) to assess preferences and trade-offs for various management options and examine factors influencing compliance behaviour. A separate survey of commercial fishers examined industry perspectives on the implications of the stock rebuilding on fisher behaviour, current management and options to reduce competition.

Surveys of the recreational fishery have been conducted since 2000, providing time series data on fisher responses to changing stock conditions. Collation and synthesis of this information was undertaken to provide context for model development, including the implications of stock rebuilding on catch rates, fisher participation, effort and harvest. Commercial logbook data were available to undertake commercial fleet analysis. The bio-economic stock assessment model used to support the management of the Tasmanian rock lobster fishery was used to evaluate the consequences of the predicted increases in recreational catch. Two sets of scenarios were considered, (i) no further management changes are introduced in response to expected increases in recreational catch, and (ii) recreational over-catch is offset by reductions in the commercial catch cap allocation. The former provides an indication of the impacts on the stock and the ability to meet east coast stock rebuilding targets if predicted catch increases are not addressed through management intervention. The latter considers the stock implications of any displacement of commercial east coast catch into the remaining stock assessment areas.

Broad fisheries policies, as well as existing and alternative management instruments and settings available to achieve the objectives of the stock rebuilding strategy were reviewed. The feasibility of alternative management options and scenarios was examined using the synthesis and survey methods described above and expert opinion. Feasibility was based on the effectiveness in achieving the rebuilding target, compliance and fisher behaviour effects which have either a neutral or synergistic effect on the effectiveness of the option, acceptability to fishers (i.e. alignment with preferences), and the practicality of implementation. The types of costs and benefits associated with alternative management scenarios were identified but, in the absence of specific policy objectives for the Tasmanian Rock Lobster Fishery, a formal cost-benefit analysis was not undertaken.

Key findings

The objective of rebuilding east coast rock lobster stocks has necessitated the implementation of measures to constrain both commercial and non-commercial catches.

For the commercial sector, the east coast catch has been significantly and effectively reduced by capping the quota that can be taken from the region. This has also involved some redistribution of effort into other regions of the state, thereby reducing the negative economic impact of this spatial management measure. Fishers acknowledge, however, that as stocks rebuild competition amongst commercial operators is expected to increase the race-to-fish. Although not a major concern for the sector, those operators with greater dependency on the east coast may experience increasing economic hardship, with the catch cap being reached earlier in the fishing season.

Recreational management settings have not, however, been effective in limiting the recreational harvest to the sector's allocated catch share. Recreational participation and effort are strongly linked to fishing success, such that as catch rates improve (with stock rebuilding) recreational effort and harvest are predicted to grow, indicating a need for additional management intervention if stock rebuilding catch targets are to be met. The primary challenge in achieving the east coast stock rebuilding objectives is, therefore, the management of the recreational component of the fishery.

Surveys of recreational fishers indicated strong opposition towards any further reduction in daily bag limit (currently two lobster), with low perceived effectiveness and support for the measure as well as confirmation that any reduction would significantly impact fishers' utility. Such a response was anticipated as rock lobster is a highly consumptive harvest-oriented fishery. A reduction in season length was another management setting that was found to significantly impact most fishers' utility. In contrast, we found heterogeneous preferences amongst fisher groups (fishing mode and avidity) for an introduced maximum seasonal catch and an increase in minimum size limits. These results may reflect the fact that these measures limit catch indirectly whereas a reduction in bag limit and shortened season have direct and clear implications on expected catch and recreation time. While there was majority in principle support for an individual maximum seasonal catch limit, the limit that would be acceptable to most (median of 20 lobsters) was significantly greater than the average individual catch required to meet the east coast recreational catch share target.

As a direct consequence of the rebuilding strategy catch rates for commercial and recreational sectors are expected to increase substantially, although for the recreational sector the catch rate increase will become increasingly constrained by the bag limit. For the commercial sector this will result in earlier and earlier closures due to the catch cap being reached; the east coast fishery is likely to become a predominantly an early season (autumn) and winter fishery. For the recreational sector and in the absence of additional management restrictions, the combined effects of higher catch rates and participation are predicted to lead to an increase in the east coast catch of between 57 and 125% above 2018/19 levels by 2023. Increases to this level will undermine the stock rebuilding strategy and prevent the stock rebuilding target being achieved in at least one of the east coast stock assessment areas.

Model projections suggest that to maintain catches within the recreational catch share allocation will require a reduction of effort to half of the 2018/19 level by 2023. To achieve this with existing input controls will be a formidable challenge, especially in the context of anticipated increased participation arising from increasing catch rates.

The alternative of maintaining the total East Coast catch at the target levels by off-setting recreational over-catch against the commercial catch share would lead to increased fishing pressure in other areas of the state. Without additional management changes this redistribution of catch is predicted to prevent achieving rebuilding targets in some stock assessment areas outside of the east coast. Consequently, management changes such as a reduction in the total allowable commercial catch allocation or further spatial management to support rebuilding in impacted areas may need to be considered.

Implications

Using a multidisciplinary approach this study has highlighted the key challenges to developing an effective management framework to support the rebuilding of the east coast rock lobster stocks. Challenges that are compounded by the lack of clear policy direction for the Tasmanian Rock Lobster Fishery. Notwithstanding this and assuming the *status quo* is not desirable it is evident that further and substantial management intervention will need to be considered if the east coast stock rebuilding goals are to be met.

Although direct management recommendations are beyond the scope of the current study there are several observations that are expected to assist in future decision making. In relation to existing management settings, season length is likely to be the most effective in constraining catches although it is clear that progressive and significant reductions would be required to achieve the recreational catch share target. Minor adjustments, as implemented in the past have not been sufficient in this regard.

In relation to alternative management options, the concept of a maximum individual seasonal catch limit has merit, not the least in that it ensures a more equitable distribution of the catch between fishers. However, without limits on the number of recreational licences issued each year such a system cannot directly control the total catch. Catch or harvest tags represent a practical means to

implement such a measure but there are risks and costs associated with implementation and administration of a such as system that require careful consideration.

In-season catch monitoring, whether based on reported tag usage, mandatory reporting or survey methods, could be applied in much the same way as the commercial catch cap is managed, i.e. the season is closed when the catch limit is reached.

It may also be reasonable to review the east coast catch share split between commercial and recreational fisheries as an element of future management direction. However, in the absence of policy guidance around fisheries allocation (or reallocation) in Tasmania any such determination would ultimately be a political decision. A re-allocation of a higher proportion of the catch share to the recreational fishery would ease the regulatory burden on the sector but would still need to ensure that recreational catches are effectively monitored and constrained within the revised catch share arrangements.

Although there may be no simple solutions to the management of this shared fishery it is hoped that the current project will assist resource managers, recreational and commercial sectors in working proactively to meet the challenges.

Keywords
Rock Lobster; recreational fisheries management; commercial fisheries management; fleet dynamics; stock rebuilding; fisher behaviour.

Introduction

Southern rock lobster (*Jasus edwardsii*)[1] support a major commercial fishery in Tasmania, with current catches of just over 1000 tonnes p.a. and a landed value of about $90 million. The commercial fishery is managed with a combination of input and output controls, including a total allowable commercial catch (TACC) allocation, individual transferable quotas, seasonal closures, gear restrictions and size limits.

The species has long represented a traditional food source for the local Aboriginal population as well as being highly prized by the recreational sector. Recreational rock lobster fishers are required to be licensed (around 20,000 annually) and although a licence is not required for Aboriginal persons, rock lobster pots and rings used by Aboriginal fishers must be marked with a Unique Identifying Code (approximately 1,700 issued since 2014[2]). Season, bag and size limits apply to both recreational and Aboriginal fishers. In addition, an allowance of 170 tonnes or 10% of the total allowable catch (TAC), whichever is the larger, has been legislated in the *Fisheries (Rock Lobster) Rules 2011* and is allocated to the recreational fishery as a total allowable recreational catch (TARC).

East Coast Stock Rebuilding Strategy

Concerns around declining rock lobster stocks in Tasmania were identified in the late 2000s and in 2011/12 east coast stocks were assessed to have hit historically low levels, attributed to a combination of years of below average recruitment and heavy fishing pressure (Hartmann *et al.*, 2013). In response, a formal stock rebuilding strategy was implemented in 2013 with a goal to rebuild east coast stocks to greater than 20% of the unfished stock level by 2023 (DPIPWE 2013). A key element of this strategy, referred to as the East Coast Stock Rebuilding Strategy (ECSRS), is to limit the average annual total catch (recreational and commercial) off the east coast of Tasmania (assessment areas 1-3, refer Fig. 1a) to 200 tonnes. However, because the rebuilding strategy was judged to be behind schedule this catch target was lowered to 195 tonnes in 2018 (DPIPWE 2018).

Under the strategy, the commercial fishery is subject to a catch cap which is monitored within the quota management system. Several management measures have been implemented to constrain non-commercial catches, including reductions in the daily bag limit and length of the recreational fishing season off the east coast. Current management instruments and settings are described in Table 1.

In 2016, the Minister for Primary Industries and Water (Tasmania) determined that the catch limit for the east coast stock rebuilding zone (ECSRZ) be split 79% to commercial and 21% to recreational sectors, reflecting the historic proportion of commercial and recreational catches from within the rebuilding zone. This sharing arrangement meant that the east coast catch target was initially split 158 tonnes to the commercial fishery and 42 tonnes to the recreational fishery. From 2017/18 the southern boundary of the ECSRZ was adjusted to a line running south from Southport to Bruny Island and then east from Tasman Head so that the zone more precisely covered the target area for stock rebuilding (Fig. 1b) (DPIPWE 2018). The revised ECSRZ catch split for 2017/18 was determined to be 134 tonnes for the commercial fishery and 41 tonnes for the recreational fishery while for 2018/19 the catch split was revised to 131 tonnes for the commercial fishery and 40 tonnes for the recreational fishery.

[1] Eastern rock lobster (*Sagmariasus verreauxi*) are also occasionally taken in Tasmania waters.
[2] UICs are required for marking rock lobster pots, set lines, gillnets or unattended rock lobster rings. As there is no gear to be marked for divers, these figures may not include Aboriginals who only dive for rock lobster.

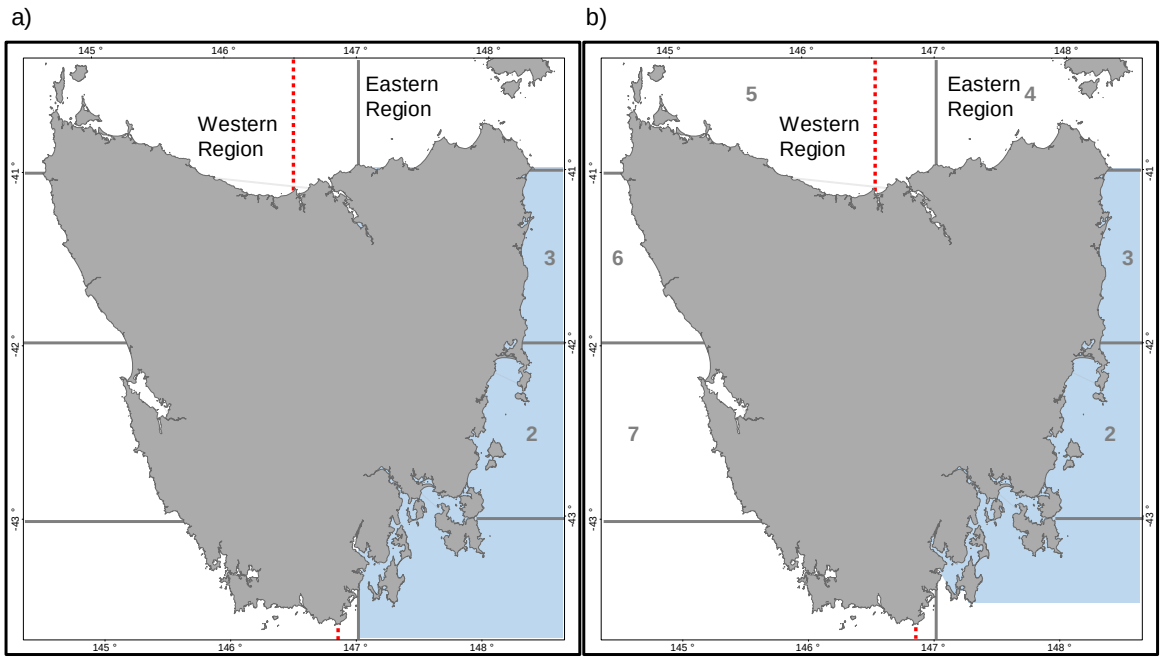


Fig 1. Map of Tasmania showing assessment areas (numbered), stock rebuilding zone (ECSRZ) (shaded) and the Eastern and Western Region boundary (red dotted line): a) ECSRZ that applied between 2013/14 and 2016/17; b) adjusted ECSRZ that applied from 2017/18.

Table 1. Summary of existing management instruments and current settings under the ECSRS (2018)

Instrument	**Current settings**		
	Commercial	**Recreational**	**Customary/Aboriginal**
Operational fisheries management			
Entry requirements	Limited entry fishery	Recreational Lobster Licence required (numbers not limited)	No licence is required, however require Unique Identifying Code (UIC) for pots and rings issued by the DPIPWE.
Output control	Individual transferable quotas (state-wide)	Daily bag (2 lobster), possession (4) and boat (10) limits	As for recreational
	Notional catch limit of 131 tonnes, including Catch Cap (competitive) of 119 tonnes	Notional catch limit 40 tonnes	
Minimum size limit (carapace length)	Females:105 mm Males:110 mm	Females:105 mm Males:110 mm	As for recreational
Fishery closure	October – mid-December (female lobster May – mid-December)	May – early December	As for recreational
Fisheries allocation policy			
Allocated catch share for ECSRZ (%)	79%	21%	Allowance (not within allocation)

Recreational fishery

Recreational rock lobster licences were first introduced in Tasmania during the late 1970s. Licences are method-based and prior to the mid-1990s consisted of pot and general dive licences, the latter permitting the capture of rock lobster, abalone, and scallops by diving. The licensing system was revised in 1995 and the general dive licence was split into lobster dive, scallop dive and abalone licences. In 1998, a lobster ring licence was introduced to formally recognise this capture method in the licensing system. Pot fishers are permitted to use one pot, ring fishers up to four rings, and divers can use artificial breathing apparatus (scuba or surface air supply, the latter commonly known as hookah).

Licences are issued annually, with the licensing year extending from November to October in the following year. In a given year, recreational fishers may hold any combination of the three categories of lobster licence (pot, ring and/or dive)[3]. In addition to licensing, minimum size limits, closed seasons, and a ban on the taking of females carrying eggs, referred to as 'berried', apply to rock lobster. Recreational fishers are also subject to daily bag, possession and boat limits for rock lobster.

Following the introduction of the current licensing system, the number of persons holding recreational rock lobster licences more than doubled, from about 8500 in 1995/96 to 21,000 by 2007/08 (Fig. 2). Increases occurred in each of the licence categories, with over 18,000 pot, 9,000 dive and 5,600 ring licences issued in 2007/08. Licence numbers remained relatively stable up until 2009/10, then declined over the following three seasons before increasing slightly to levels comparable to the mid-2000s. A sharp fall in licence numbers was experienced in 2015/16, largely influenced by closures of parts of the east coast early in the season due to harmful algal blooms (biotoxin events). Similar biotoxin closures occurred during 2017/18, contributing to a 5% decline in licence sales compared to the previous season. In 2018/19, more than 18,000 persons held at least one rock lobster licence, with 15,000 pot, 8,450 dive and 4,300 ring licences issued.

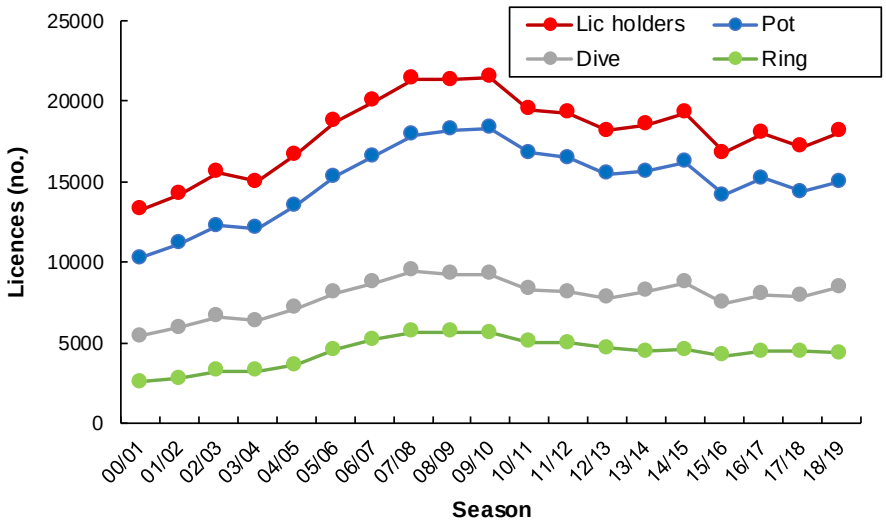


Fig. 2. Numbers of recreational rock lobster licence-holders and licence categories issued by licensing year.

Recognising a need to focus management action off the east coast, the fishery was divided into Eastern and Western Regions in 2011/12 (Fig. 1). In that same year, Eastern Region bag and possession limits were reduced from 5 to 3 and from 10 to 6 lobsters, respectively along with the introduction of a boat limit of 15 lobsters (Fig. 3). These limits were further reduced in 2015/16 (bag limit of 2, possession limit of 4 and boat limit of 10) along with a progressive reduction in the duration of the season in the

[3] Note, the licensing system also includes abalone, gillnet, beach seine, setline and scallop licence categories.

Eastern Region, acknowledging that greater restrictions were required if the recreational harvest was to be constrained to within the ECSRS catch sharing arrangement (DPIPWE 2018). These management changes, in conjunction with lower stock abundance (catch rates) and the impacts of recent biotoxin events, appear to have contributed to the fall in licence numbers. For instance, in the four years prior to 2011/12 licence numbers averaged almost 21,000, compared to an average of 18,800 between 2011/12 – 2014/15 and 17,500 since 2015/16 (Fig. 3).

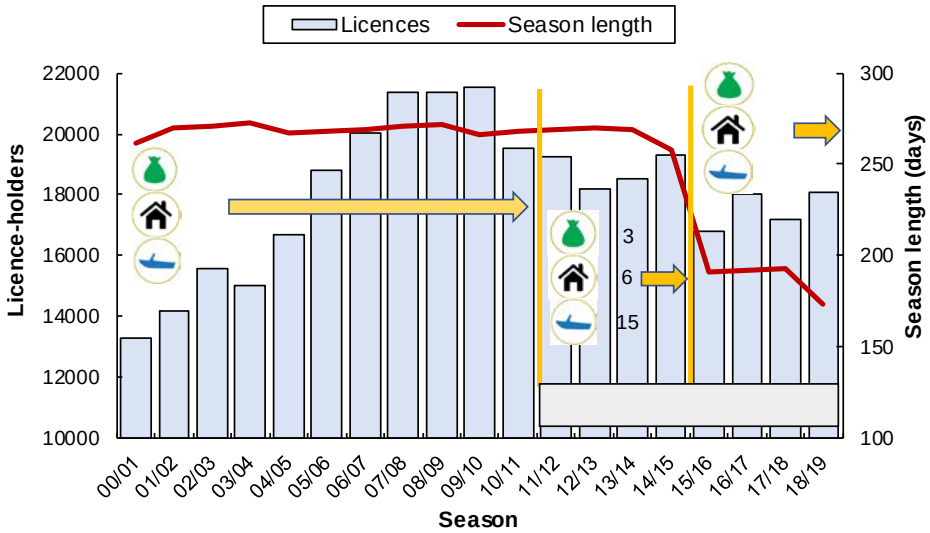


Fig. 3. Chronology of changes in the Tasmanian recreational rock lobster fishery: number of licence-holders and key management measures relevant to the Eastern Region, including duration of the fishing season,bag , possession and boat limits.

The recreational fishery has been monitored using fisher surveys since 2000[4] (e.g. Lyle 2018), during which time stock abundances have varied markedly and there have been several management changes, mainly centred on the east coast. State-wide recreational catch, effort and catch rates have declined since the early 2000s, from a peak catch of almost 150 tonnes in 2002/03 (Fig. 4). The initial decline occurred despite a steady increase in licence numbers, which peaked during the late 2000s (refer Fig. 2), and corresponded with a general decline in overall stock abundance (Hartmann *et al.* 2013) but was also influenced by changed management settings introduced as a component of the ECSRS. Overall, the state-wide harvest has not exceeded the TARC allocation of 170 tonnes in any year for which there is survey data. Since 2015/16, estimated harvests have been equivalent to about half of TARC.

[4] Surveys were conducted on a biennial basis between 2000/01 and 2014/15 and annually since 2015/16.

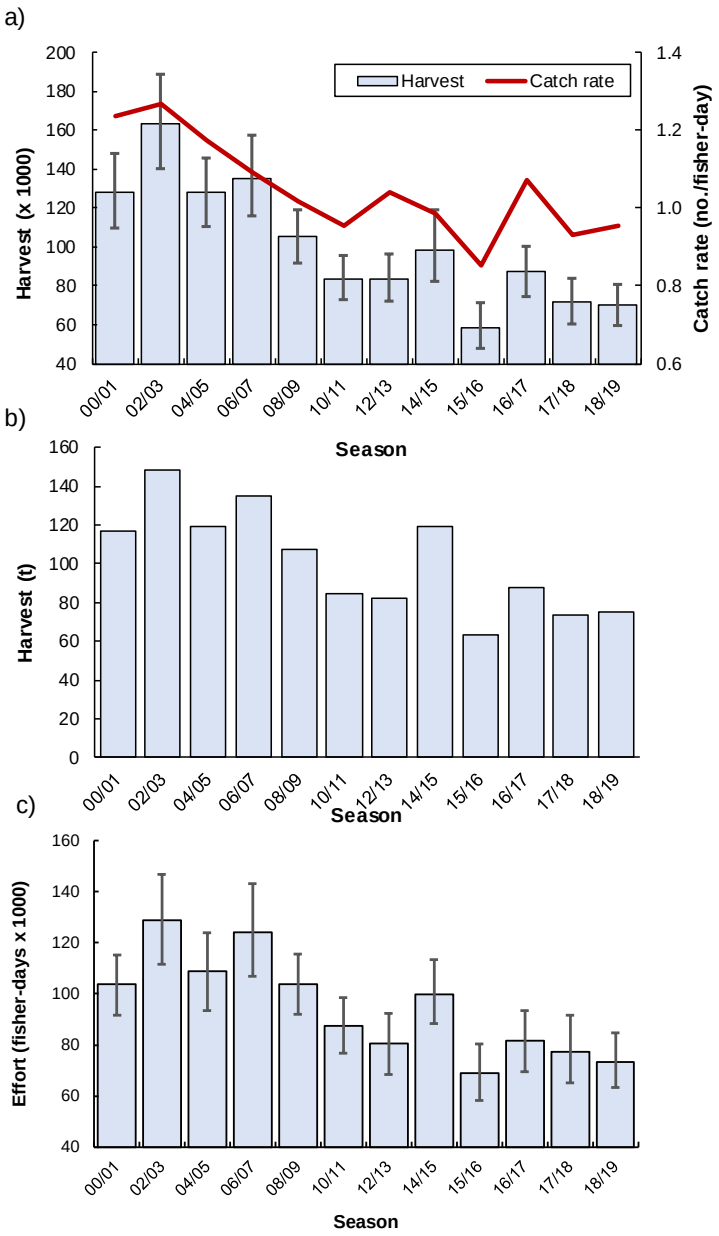


Fig. 4. Tasmanian recreational rock lobster fishery: a) estimated state-wide harvest (numbers) and average catch rate (number per fisher-day); b) estimated state-wide harvest (tonnes), c) effort (fisher days) by fishing season. Error bars indicate 95% confidence interval on estimates (based on Lyle, 2018, unpubl. data).

East coast recreational fishery

The East Coast (assessment Areas 1-3, refer Fig. 1a) has traditionally accounted for 60-70% of the state-wide recreational catch and effort (e.g. Lyle 2018), the estimated harvest peaking at between 80-100 tonnes per annum during the early to mid-2000s (Fig. 5). Catches declined steadily to 2012/13 and have flucutated thereafter at between 40-50 tonnes per year. Pot catch rates, which have been less influenced by the bag limit reductions than dive catch rates[5], have followed a similar pattern to that of catches (Fig. 5). While there was an increase in pot catch rates during 2016/17, the higher catch rate was not sustained in the following seasons despite the expected increase in fishable biomass on the east coast.

[5] Note, even when pot catch rates peaked during the early 2000s and the daily bag limit was set at five lobster, less than 10% of all recreational pot sets resulted catches of more than two lobster.

During 2012/13, toxic algal blooms resulted in the closure of the fishery in Area 3 and a large part of Area 2 during the peak fishing period (November – January), resulting in a marked reduction in fishing activity in these areas (Lyle and Tracey 2014). In the same year, major bush fires impacted several east coast communities, including the Tasman Peninsula, further contributing to a decline in recreational effort (Lyle and Tracey 2014). As a result, and despite pot catch rates being higher than in 2010/11, the resulting east coast harvest was lower in 2012/13(Fig. 5).

Since the implementation of the ECSRS in 2013 and despite changes to key management settings (bag limits and season length) recreational catches in the rebuilding zone have exceeded the sector's catch share allocation in all but one year (2015/16) (Fig 5b). In 2015/16, and more recently in 2017/18, biotoxin closures off the East Coast (Fig. 6) have had marked impacts on the recreational fishery. These closures and associated uncertainty surrounding opening dates effectively reduced fishing opportunities, with many licence-holders confirming that they had fished less than normal as a direct result of the biotoxin closures (Lyle and Tracey 2016b, Lyle 2018). Furthermore, by delaying fishery access to a period when catchability is lower (Ziegler *et al.* 2004), the closures also appeared to have negatively impacted catch rates. This situation was exacerbated in 2015/16 with the east coast of Tasmania experiencing a major marine heat wave event (Oliver *et al*. 2017) that may have further reduced lobster catchability, contributing to the lowest catch rate for the period. It is probable therefore, that in the absence of the biotoxin closures, the recreational catches in these years would have been much higher.

Thus in spite of greater restrictions (lower bag and possession limits, reduced season duration), the sector has continued to take or has the capacity to take catches that exceed the notional catch share in the ECSRZ under current management settings. Furthermore, illegal catches through unlicensed operations or breaches of regulations are not included in recreational catch estimates and the level of non-compliance is currently unknown. This gap in knowledge potentially threatens the value of the shared resource, which not only has social and economic implications, but also affects a species that has an important role in the ecosystem dynamics of Tasmania's rocky reef systems.

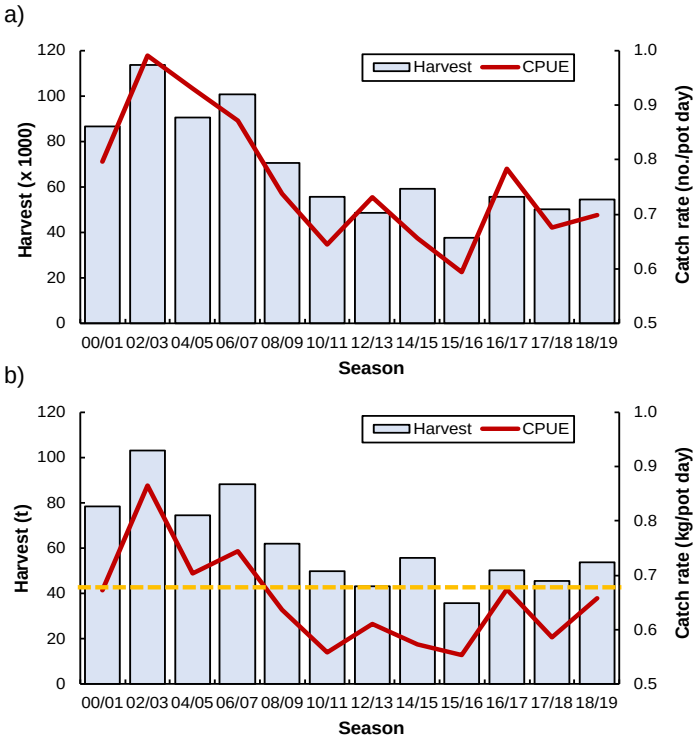


Fig. 5. East Coast (assessment areas 1-3) recreational rock lobster harvest and pot catch rates by a) numbers and b) weight. Dotted line (42 tonnes) is provided as reference to the initial ECSRS catch share arrangement.

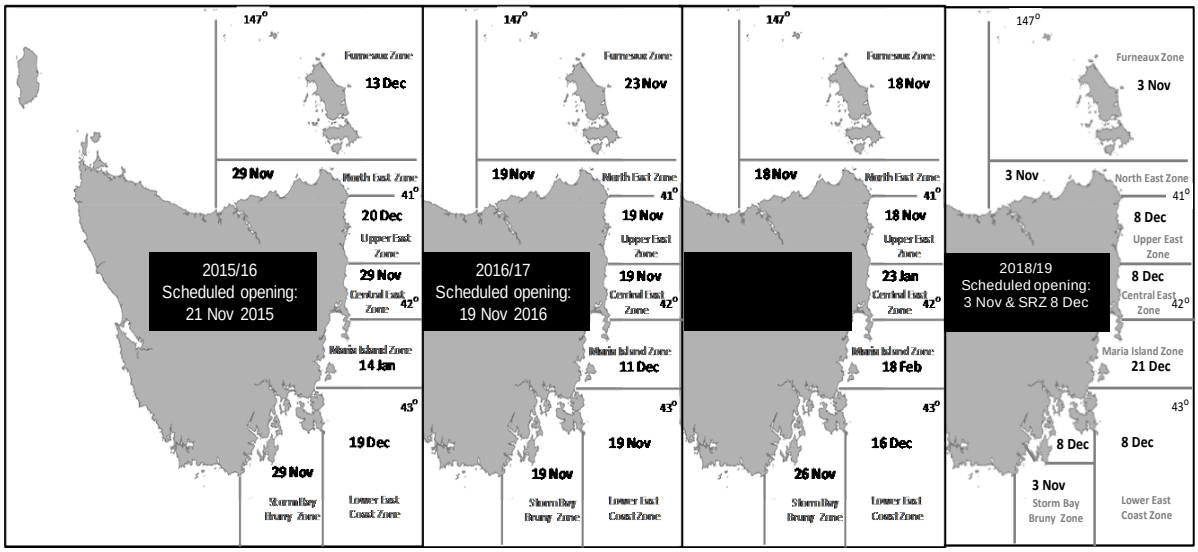


Fig. 6. Maps showing biotoxin zones and the impact of biotoxin events on opening dates for the 2015/16, 2016/17, 2017/18 and 2018/19 seasons. Scheduled Eastern Region opening dates are shown.

Commercial fishery

Commercial rock lobster harvests were managed by input controls until March 1998 when a quota management system was introduced. Consequently catches prior to March 1998 exhibited substantial inter-annual variability (Fig. 7) in response to variable recruitment and economic circumstances (beach price, fishing costs etc.). From 1998 onwards catches were stabilised by the TACC and the stock started rebuilding (as evidenced by increasing CPUE). In the late 2000s what we now understand was a record low recruitment event (Linnane *et al*. 2010) led to an abrupt decline in stock and a reduction in TACC to the current level of 1050.7 tonnes, the lowest commercial catch since the 1950s.

This reduction in catch has led to stock rebuilding which has been most pronounced in the last two years (2016/17 and 2017/18) in response to a recruitment pulse. The present commercial catch is taken from areas all around Tasmania and involves an annual harvest of around 1.1 million animals. In the 2017/18 season[6] 194 licensed vessels reported catches of rock lobster, an ongoing decrease from almost 300 vessels that operated when the quota management system was introduced for the 1998/99 season.

In the last five years there has been an increasing focus on regional rock lobster management. This is appropriate for this fishery as adults do not move large distances, the habitat varies greatly in accessibility to both recreational and commercial fleets and biological characteristics such as growth and size at maturity vary substantially throughout the state (Gardner *et al*. 2006). Consequently, regions such as the East Coast (areas 1-3) and North-West (area 5) have seen far greater exploitation and require regional management to ensure sustainable populations. To this effect regional management measures have been introduced, including the east coast stock rebuilding strategy considered here, a commercial catch cap for the North East (area 4), higher pot limits on the West Coast (areas 6-8) and regional size limits are under consideration for the North-West (area 5)[7].

[6] Commercial quota year is between March and February whereas the recreational licensing year is between November and October.

[7] Areas are stock assessment areas shown in Fig. 1.

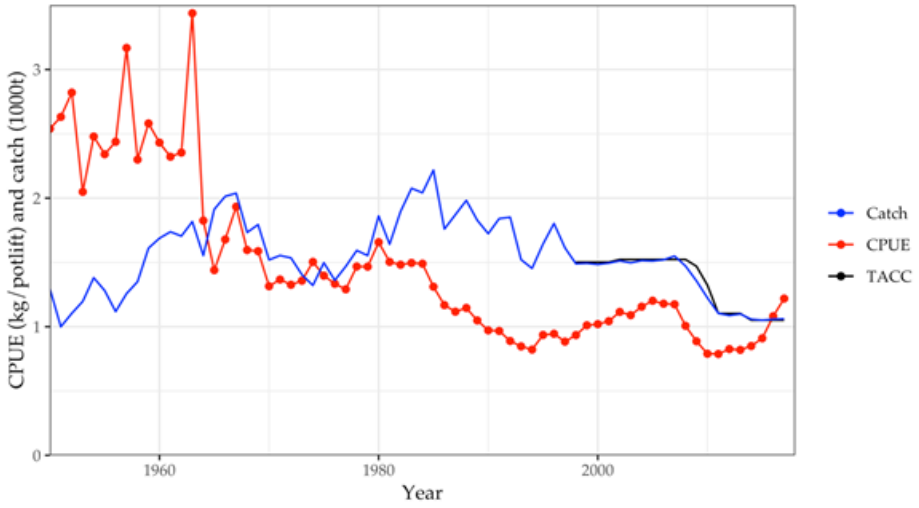


Fig. 7. Commercial rock lobster catch (tonnes), CPUE (kg/potlift) and TACC (tonnes).

East Coast commercial Fishery

Due to factors including accessibility and consequent lower operating costs the East Coast has continued to be fished at lower stock abundance than many other areas in Tasmania. For example, despite low CPUE, the profit from a low-cost fishing trip to the East Coast can be similar to a trip to high CPUE areas in the Southwest due to higher fuel costs, time spent travelling and time lost due to weather windows. This is illustrated in Fig. 8 which shows that CPUE in the East Coast areas is consistently below the Tasmanian average.

Catch from the East Coast fishery declined in the late 2000s, initially in response to the rapid decline in CPUE, then additionally in response to the decreasing TACC (Fig. 9). The subsequent introduction of the ECSRZ catch cap has maintained the commercial catch at low levels despite increasing stock abundance and CPUE in the ECSRZ. This has resulted in a race-to-fish with the catch cap being reached before the end of the fishing season. In turn this shortening of the season has resulted in more limited opportunities for commercial operators to fish the East Coast, particularly for operators that are operationally constrained to this area (due to vessel size, business structures etc.).

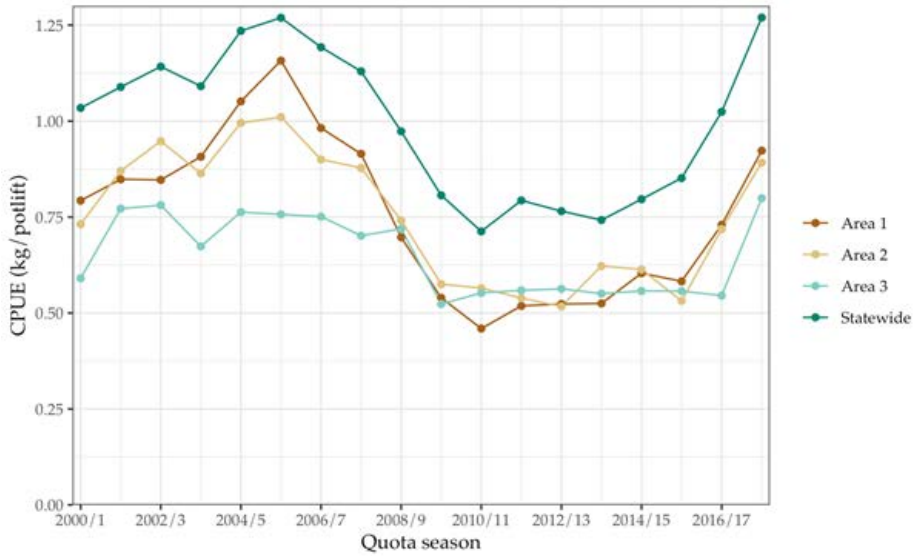


Fig. 8. Standardised CPUE (kg/potlift) in East Coast assessment areas (1-3) and State-wide.

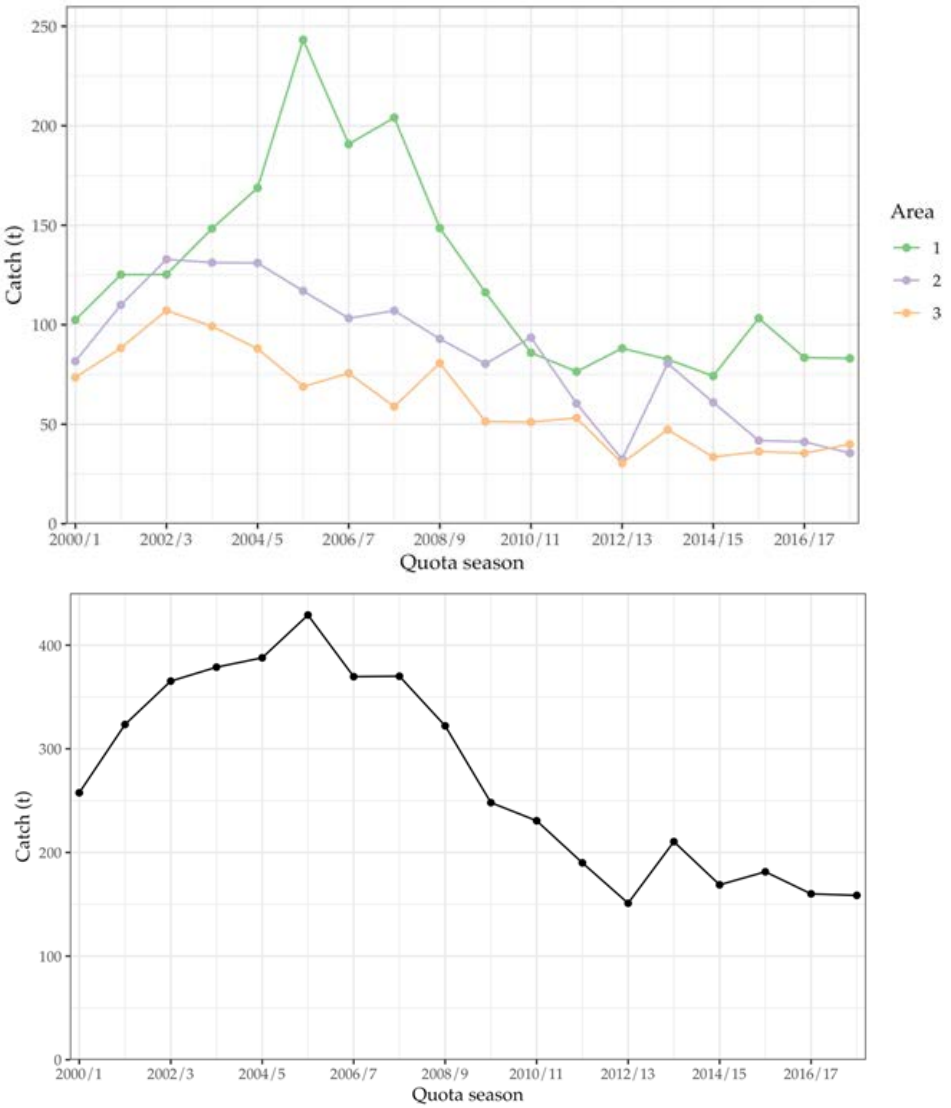


Fig. 9. Commercial rock lobster catch in the three east coast assessment areas (top panel) and for the entire east coast (bottom panel)

Objectives

Within the context of the east coast stock rebuilding strategy, high and varying levels of participation will make management of the recreational component of the fishery challenging. This situation is likely to be further exacerbated as stocks continue to rebuild, and higher catch rates are expected to attract increased effort and overall catches for the sector. By contrast, for the commercial sector, the catch cap effectively represents a competitive catch quota which, as catch rates improve, is likely to influence fleet dynamics as fishers' race to take the limited catch.

Understanding relationships between fisher behaviour, their expectations/aspirations, responses to changes in stock status and to management intervention is critical when implementing effective management strategies. This project aims to inform on the practical challenges to achieving the east coast stock rebuilding objective and provide options to assist managers and both fishing sectors in achieving the ecological, social and economic goals for the fishery.

Specific objectives of this study include:

1. Determine the relationships between recreational fisher behaviour (effort and participation) and rock lobster catch rates and abundance.
2. Assess fisher attitudes and compliance behaviour to management scenarios designed to achieve the east coast stock rebuilding objective.
3. Model the effectiveness of alternative management scenarios in constraining recreational catches as stock rebuild.
4. Model the impact on fleet dynamics, including economic implications, of the expected shift to an "Olympic" or competitive quota.
5. Evaluate the costs and benefits of short- and long-term management options for the east coast rock lobster fishery.

Methods

Overview

The following methods were applied to address the objectives:

- recreational fisher surveys (objectives 2 and 3)
- commercial fisher survey (objective 4)
- synthesis of available recreational fishery information (objectives 1 and 3)
- modelling of fisher behaviour (objectives 3 and 4)
- expert-informed analysis of policy settings and scenarios (objectives 2, 3 and 5)

Recreational fisher surveys

Two complementary recreational fisher surveys were undertaken as part of this study. An initial survey was conducted by telephone between May and June 2018 (*phone survey*) and was based on a random sample of rock lobster licence-holders selected from the recreational licensing database administered by the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE) (Appendix 4). Participants included persons who had recently completed the 2017/18 rock lobster diary survey, with initial selection for the diary survey based on a regionally stratified survey design drawn from the 2016/17 licence database (refer Lyle 2018). This "diary sample" was supplemented with a random sample of licence-holders drawn from the 2017/18 licence-database but limited to residents of Australian Bureau of Statistics statistical areas (SA4) that border on the east coast of Tasmania; namely Hobart, Launceston and North East, and South East (Pink 2011). This "supplementary sample" was intended to boost the survey sample and, being restricted to residents of regions adjacent to the ECSRZ, ensure strong representation from respondents who had experience and/or interest in the east coast rock lobster fishery.

The phone survey also served to recruit respondents for a follow-up survey that included a discrete choice experiment (DCE) to assess preferences for various management options and examine factors influencing compliance behaviour (Appendix 5). Phone survey respondents who indicated that they usually fished off the East Coast (areas 1-3) were deemed eligible for this *DCE survey*. The DCE survey was offered on-line (SurveyMonkey) or by mail depending upon respondent preference and was open from May to October 2018.

Phone survey

The phone survey was restricted to respondents aged 18 years or older. The questionnaire (Appendix 4) involved a series of profiling questions that included years of recreational fishing experience (general and rock lobster fishing), number of days normally spent fishing (general and rock lobster), regions normally fished for rock lobster (east/south east, north, and/or west coasts), importance of fishing (general and rock lobster) compared to other outdoor activities, and fishing activities other than for rock lobster undertaken during the previous 12 months. Effort (days fished for rock lobster) and catch (numbers of lobster retained) for the 2017/18 fishing season were also recorded; based on diary data for diary sample participants (Lyle 2018) and as reported (recall) by supplementary sample participants. The licence database provided information on licences held (i.e. pot, dive and/or ring), age, gender and residence (post code) for each respondent.

Respondents were asked for their agreement to statements about fishing for rock lobster that explored aspects relevant to consumptive orientation (i.e. catch-related aspects of fishing) and behavioural responses to management and environmental factors. A series of management options intended to constrain recreational catches in the ECSRZ to the notional catch share were also presented to

respondents. Finally, respondents were asked for their opinions about non-compliance with specific regulations relevant to rock lobster.

Data analysis

To examine how factors such as 'fishing mode' and avidity influenced responses, survey participants were grouped based on their profiling data. Fishing mode, inferred from rock lobster licence categories held during 2017/18, was defined as *pot* (pot and/or ring licence only), *dive* (dive licence only) or *multi-method* (dive and pot and/or ring licences). Avidity was based on the reported number of days fished for rock lobster during 2017/18 and was grouped as follows, 0-5 days, 6-10 days, 11-20 days, >20 days.

The effect of each of the grouping factors on answers to questions using Likert-scale responses was explored with Kruskal-Wallis tests using the "kruskal.test" function in R. When significant differences were identified, post-hoc pairwise comparisons were made using the "pairwise.wilcox.test" function in R with alpha values corrected for multiple pairwise comparisons with the Bonferroni-Dunn method (Dunn, 1964; Pohlert, 2014). Chi-square tests were applied for dichotomous choices (e.g. support/not support; effective/not effective). The level of statistical significance was set at $\alpha = 0.05$.

Discrete choice experiment

Conceptual framework

Discrete choice experiments are a survey-based stated preference approach that can elicit respondents' preferences for a good in question, such as preferences for different management instruments and settings. DCEs evolved from Lancaster's (1966) theory of consumer behaviour, in which the utility derived from an alternative is associated with the attributes of the alternative. In this context, utility is characterised based on the assumption that respondents choose the alternative that provides the greatest utility for them (Adamowicz *et al.* 1998). Although a number of challenges have been identified (Carson 2012; Hausman 2012), the usefulness of DCE to support policy-making has been widely acknowledged (Rogers *et al*. 2015; Marre *et al*. 2016). The main advantage of DCE over opinion-based surveys is that survey respondents are placed in a choice situation requiring them to consider trade-offs between attributes and to choose the alternative that provides the greatest utility.

Discrete choice experiment design

Alternatives in a choice task are defined by a set of attributes and their levels. Table 2 provides the description of each attribute (management instrument) and associated levels (settings) used in this study. Attribute and level selection was based on a number of sources, including: i) a discussion paper summarising management options to restrain rock lobster catches (DPIPWE 2016b); ii) previous fisher surveys (e.g. Lyle and Tracey 2016a,b; 2017); and iii) extensive discussions with fishery experts. Since the fishery is predominantly consumptive and the primary objective was to examine management preferences, attributes around the fishing experience were not included in this component of the project.

To determine the number of attributes and the levels, management restrictions which are already in place or have been discussed to be used in future management were first identified. Five restrictions considered as effective at reducing catch in this fishery and having clear links to recreational fishing experience were selected as management attributes. The attributes included in the DCE were: (1) daily bag limit, (2) season length, (3) maximum seasonal catch limit per person, (4) minimum size limit and (5) penalties for non-compliant acts.

The daily bag limit at the time of study was two lobster. The bag limit had been reduced from five to three in 2011 and then to two lobster per day in 2015. Therefore, we considered a further restriction to one, as well as renewing the bag limit to three as levels for this attribute.

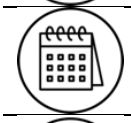
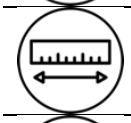
The levels for the season length and maximum seasonal catch limit were set within the average ranges of seasonal catch and frequency of fishing events found in previous surveys (Lyle and Tracey, 2016a,b; 2017; Lyle, 2018).

An increase in the minimum size limit for females is another restriction that has been proposed as a measure to assist with stock rebuilding by providing additional protection to the adult (female) stock and enhance egg production. Levels of this attribute were set relative in scale to size increases that would provide at least a year of additional protection to breeding females but also effectively reduce catch rates (and hence total harvest by numbers[8]).

Finally, regarding penalties for non-compliance, we were non-specific with the non-status quo level and alternative since a penalty for a non-compliant act can take many forms. All attributes, except maximum individual season limit, are already in place – with the status quo representing the current (2018) management situation.

There is currently no limit on the maximum number of lobsters a licensed fisher can catch in a season, however, implementing such a restriction has been discussed with resource managers and stakeholders as a potential tool to reduce the overall recreational catch (and more equitably share the catch within the sector). For the purposes of the DCE, the effective status quo seasonal catch limit was presented as 40 lobster (4 to 5 times higher than the reported individual average seasonal harvest, e.g. Lyle 2018).

Table 2. Attributes and levels used in discrete choice experiment

Attribute	Description	Levels					
		Status Quo 0	1	2	3	4	5
 1. Daily bag limit	The number of rock lobster that any licensed fisher can legally retain per day	2/ day	1/ day	3 / day			
 2. Season length	The number of weeks the fishing season is open	24 weeks (As for 2018)	16 weeks	8 weeks			
 3. Maximum seasonal catch	Maximum number of one licenced fisher can keep over the entire season	40	8	12	16	20	24
 4. Minimum size limit for females	Minimum legal size limit for female rock lobster	Current (105mm)	Increase by 5 mm	Increase by 10 mm			
 5. Penalties for non-compliant act	The penalty given for non-compliant acts	Current	Increase by 50%				

In total, there were 324 combinations for the five attributes and associated levels in Table 2. It is not feasible to ask respondents to select their choice from the universe of all possible combinations. Relevant combinations of attribute levels can be generated in multiple ways, such as orthogonal designs (Louviere *et al*. 2000) or efficient designs (Rose & Bliemer 2009). In this study, an efficient design was used to avoid unrealistic scenarios in the management context of this fishery. Using *a priori* expectations of the parameter estimates, efficient designs can also improve the reliability of the estimated parameters (i.e., standard errors) for a given sample size (Huber & Zwerina 1996). The

[8] An increase in minimum size limit would result in more of the catch being undersized and thus released.

utility for each attribute was modelled using Ngene (ChoiceMetrics), which produced 18 choice sets (i.e., scenarios) with balanced utility, as per the efficient design. While it is possible for respondents to answer all choice sets, it is common to divide the choice sets into blocks to make the DCE quicker to complete and reduce participant fatigue. This study comprised three blocks of six choice sets, the order of each of the blocks was randomised into five orders to minimise any ordering effects. The order and block of the choice sets was randomly allocated per respondent.

For each choice set, respondents were asked to compare the options and decide which option they would choose to renew their licence for, or whether they would choose not to renew their licence (Fig. 10). Following the choice task, respondents were asked to complete a self-assessment on the understanding and confidence in completing the DCE. Respondents who opted out for every choice set (i.e. indicated they would not renew their licence) were removed from the analysis as these were considered protest votes (n=6), and those who answered 'not certain at all' to conducting the choice experiment were also removed (n=7).

In addition to the choice sets, data on fishers' participation (days fished), lobster fishing methods, demographics, and motivation and attitudes towards compliance management (to complement the phone survey) were collected in the same questionnaire (Appendix 5).

Scenario 1 (out of 6)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

You should base your preferences considering your actual fishing experiences, for instance consider these options in relation to how often you go (or would hope to go) fishing/diving for lobster, your usual catch rates and the sizes of the lobsters you normally catch.

Management feature	Option A	Option B	Option C
Daily bag limit	2/ day	2/ day	I wouldn't renew my licence
Season length	8 weeks	16 weeks	
Maximum seasonal catch limit per licence holder	12 lobsters/ season	8 lobsters/ season	
Size limit for females	Increase by 10mm	As is	
Penalties for non-compliant acts	As is	Increase by 50%	

A1a) Which of these options do you prefer? (Please tick)
Option A_____Option B _____ Option C _____

A1b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)
Option A_____Option B _____

Fig. 10. An example choice set given to fishers

Data analysis

Analysis relies on a random utility model, in which U_{nsj} denotes the utility of alternative j chosen by respondent n in choice situation s, and the utility U_{nsj} has two separate components: i) an observable component of the utility, V_{nsj}; and ii) unobservable component, ε_{nsj}, such that:

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj} \quad (1)$$

The observable component of the utility, V_{nsj}, is expressed in terms of a linear combination of k attributes, such that:

$$U_{nsj} = \beta X_{nsj} + \varepsilon_{nsj} \quad (2)$$

where X_{nsj} is a vector of k observed attributes for the good in question and β is a vector of the corresponding parameters (i.e. marginal utilities). In choice situation s, respondent n will choose alternative j if $U_{nsj} > U_{nsi}$ for all $j \neq i$. Assuming a Type I extreme value distribution for the unobservable component, ε_{nsj}, the probability that respondent n chooses alternative j in choice situation in s is given by (McFadden 1981):

$$\text{Prob}\left(y_{it} = j\right) = \frac{\exp\left(\beta X_{nsj}\right)}{\sum_{s=1}^{S} \exp\left(\beta X_{nsj}\right)} \quad (3)$$

Equation (3) provides a basis to model the choices made by respondents in DCE as a function of the attributes. That is, discrete choice data is used to determine the attributes, which are significantly associated with respondents' utility, and the extent to which respondents are willing to trade one attribute for another or rather opt-out.

Discrete choice data from the DCE were modelled by a conditional logit model which estimates the marginal utility associated with each attribute; i.e., β in Equation (3). Estimates of the marginal utility were then used to assess if and to what extent respondents are willing to trade one management attribute for another while maintaining the same level of utility. For this, the marginal rate of substitution between two attributes provides an estimate of the relative importance of one attribute compared to the other. In this study, the ratio of marginal utilities of attributes (2)-(5), relative to the reduction of bag limit by one lobster are assessed. For example, the ratio $\beta_{season\ length}/\beta_{bag\ limit}$ represents, if the bag limit was reduced by one, how long the season length would have to increase to account for the loss of utility.

To examine heterogeneity in preferences, the model was estimated for the entire sample, and then for the sub-sample of fishers who reported using different fishing modes (namely: *pot*[9], *dive* or *multi-method*) and those who had different avidity levels (namely: *low avid* ≤ 10 days; *mid-avid* 11-25 days; *high avid* >25 days fished for rock lobster in the previous 12 months[10]).

Commercial fisher survey

The commercial fisher survey was targeted at commercial rock lobster fishers and was promoted by the research team at port meetings as well as by the executive of the Tasmanian Rock Lobster Fishermen's Association. The survey was offered on-line (SurveyMonkey) or by mail. The on-line survey was open between mid-June and early August 2018 while questionnaires with prepaid return envelopes were distributed to fishers at port meetings.

[9] Includes pot and/or ring methods.

[10] Note: a different avidity classification to the phone survey was used in order to reduce the number of groups in response to smaller available sample sizes and the fact that these data were based on respondent recall.

A structured questionnaire collected the following profiling information; demographics (age and residence post code), years of experience in the rock lobster industry, quota holdings in 2017/18 (owned and leased), operational characteristics (vessel size, main port of landing, number of pots licensed to carry) and proportion of the respondent's 2017/18 catch taken from the ECSRZ (Appendix 6).

Respondents were presented with a series of statements regarding implications of the east coast catch cap being reached, likely implications for the fishery (competition) of increased catch rates as stocks rebuild, perceptions on the current management of the ECSRZ and effectiveness and support for a range of alternative options designed to reduce competition within the sector and slow the rate that the east coast catch cap is reached.

Data analysis

To account for possible heterogeneity based on fishing reliance on the east coast, respondents were classified into three groups according to the stated proportion of their 2017/18 rock lobster catch taken from the ECSRZ, namely *most* (>75%), *some* (<75%) and *none* (0%). Chi-square tests were applied to test for differences between groups. Unsure, not applicable, and skipped responses were excluded in these comparisons.

Recreational fishery data synthesis

Surveys of the recreational fishery conducted since 2000 provide detailed information about the activity of individual survey participants, including the date, location, method and catch for each day fished for rock lobster (e.g. Lyle 2018). This dataset represents a comprehensive time series of fisher behaviour that can be analysed in terms of the numbers (or proportion) of active fishers, individual fishing effort (average days fished) and individual catches (average catch of lobsters). When correlated against catch rate, these attributes provide insight into potential fisher responses to stock recovery (i.e. increasing catch rates) and future challenges in constraining the recreational harvest to within the catch share. This fishery data provides key background information to support the modelling of fisher behaviour, and in particular model projections.

Recreational catch projections

To estimate future recreational catches the impact of increasing catch rates and recreational participation was considered. Commercial catch rate (CPUE; catch per unit effort) projections from the Tasmanian rock lobster stock assessment model were used as the basis for calculating future recreational catch rates. The method below was used to adjust the commercial CPUE projections to take into account the inherent differences in the recreational fishing sector. This method was applied individually for both recreational potting and diving individually in each assessment area.

The first step is to remove the impact of the bag limit from recreational CPUE. Modelling catches using a poisson distribution and assuming catches of more than two lobsters are truncated at two, the expected recreational CPUE in the absence of a bag limit (which we refer to as uncapped CPUE) is given by:

$$\widehat{rCPUE}_{\alpha,\beta,\gamma} = -LamberW\left(\frac{rCPUE_{\alpha,\beta,\gamma} - 2}{e^2}, -1\right) - 2, \qquad \gamma \leq 2018$$

where $rCPUE_{\alpha,\beta,\gamma}$, denotes the recreational CPUE (in numbers/potlift) estimated by the recreational surveys for gear α (dive, pot or ring), in stock assessment area β during fishing season γ.

Additional differences between commercial and recreational sectors were accounted for by scaling the entire projected commercial CPUE time series in each assessment area. This produces CPUE projections more representative of each gear type. The scaling factor was chosen as the ratio of the mean commercial and mean recreational CPUE in 2018. Formally the adjusted commercial CPUE is given by:

$$\widehat{rCPUE}_{\alpha,\beta,\gamma} = \frac{CPUE_{\alpha,\beta,\gamma}\widehat{rCPUE}_{\alpha,\beta,2018}}{CPUE_{\alpha,\beta,2018}}, \qquad \gamma > 2018$$

where $CPUE_{\alpha,\beta,\gamma}$, denotes the commercial CPUE estimated by stock assessment model.

To produce recreational CPUE projections that account for the bag limit, the catch for an individual fishing event was modelled as a poisson distribution with a mean equal to $\widehat{rCPUE}_{\alpha,\beta,\gamma}$. The recreational CPUE (rCPUE) is equal to the probability of catching one lobster and retaining one plus the probability of catching two or more lobsters and retaining two. Denoting the probability of retaining *i* lobsters by $p_{i,\alpha,\beta,\gamma}$, the recreational CPUE is given by:

$$\begin{aligned} rCPUE_{\alpha,\beta,\gamma} &= p_{1,\alpha,\beta,\gamma} + 2\sum_{i=2}^{\infty} p_{i,\alpha,\beta,\gamma} \\ &= 2 - p_{1,\alpha,\beta,\gamma} - 2p_{0,\alpha,\beta,\gamma}. \end{aligned}$$

Where from the definition of the poisson distribution:

$$p_{i,\alpha,\beta,\gamma} = \widehat{rCPUE}_{\alpha,\beta,\gamma}{}^{i} e^{-\widehat{rCPUE}_{\alpha,\beta,\gamma}}/i!$$

A lower bound on likely future recreational catches was obtained by multiplying the recreational CPUE for each area and gear type by the recreational effort for that area and gear type in the 2018/19 assessment year.

$$Catch_{\alpha,\beta,\gamma} = rCPUE_{\alpha,\beta,\gamma} \times effort_{\alpha,\beta,2018}$$

This assumes that recreational effort will remain constant, despite increasing CPUE.

In reality, recreational effort is likely to increase due to increased participation by both new and existing recreational fishers in response to increasing CPUE and consequently recreational satisfaction. A GLM was produced relating total recreational licence numbers to the licence numbers in the previous season, state-wide CPUE (including lags up to two years) and east coast CPUE (also including lags up to two years). The model selected based on AIC included only the number of licences in the previous season and the east coast CPUE in the previous season.

This GLM was used to iteratively forward project total licence numbers. The number of these licences accessing the East Coast (areas 1-3) was estimated by applying the 2017/18 (most recent available) proportion (Lyle 2018). Similarly, the level of effort in each area was estimated by applying the effort per person from the 2017/18 recreational assessment to the projected number of licences accessing the East Coast. Using this revised higher level of effort in the previous equation gives a higher recreational catch estimate.

An alternative, simpler approach would be to develop a model directly for the effort in each area. However, the available recreational survey data at this level does not extend back as far as overall licence data and does not include the full period of increasing CPUE during the early 2000s, which provides important information on the capacity of the recreational fleet to respond to increasing CPUE.

Commercial fleet analysis

Commercial logbook data was obtained from DPIPWE. Logbook data consists of records of individual shots, with numbers of retained lobsters – weights are not determined at sea. The catch weight for individual shots is estimated from the average lobster weight at the subsequent unloading – unloading weights are reported with high accuracy as part of the quota monitoring system. This method is utilised in the annual stock assessment.

Model projections

The bio-economic stock assessment model used to support the management of the Tasmanian rock lobster fishery (Gardner *et al*. 2015) was used to evaluate the consequences of the predicted increases in recreational catch. This provides an indication of the impacts on the stock and the ability to meet east coast stock rebuilding targets if the predicted catch increases are not addressed through management intervention.

Two sets of scenarios were considered. The first investigated a situation where no further management changes are introduced in response to the expected increase in recreational catch. This would result in additional pressure on the east coast stocks and undermine the rebuilding strategy. This is compared with the situation where the recreational catch is maintained (through unspecified means) at the current catch share split of 40 tonnes per annum.

The second set of scenarios considered the situation where recreational catches in excess of the catch share split are offset by equivalent reductions in the east coast commercial catch cap allocation. This would effectively mean that the rebuilding trajectory defined within the ECSRS was maintained. However, in this scenario it is assumed that any displacement of commercial catch from the east coast would be directed to the remaining stock assessment areas. In effect, there would be no adjustment in the state-wide total allowable commercial catch (TACC). Again, outcomes are compared with a situation where the catches outside of the ECSRZ are maintained at current levels.

Policy analysis and scenario development

Broad fisheries policies, as well as existing and alternative management instruments and settings available to achieve the objectives of the ECSRS, were identified from a number of sources, including: i) the *Living Marine Resources Management Act 1995*; ii) the East Coast Stock Rebuilding Strategy; iii) a discussion paper summarising management options to restrain rock lobster catches (DPIPWE, 2016b); iv) discussions with fishery managers and industry representatives; and (v) results of fisher surveys (e.g. Lyle and Tracey, 2016a; 2017, present study). Review of these documents was undertaken to establish:

- current management instruments and settings for the East Coast Stock Rebuilding Zone (Table 1)
- alternative management options and scenarios (Table 3);
- the policy basis for assessing fishery outcomes, and comparing the outcomes of alternative management options and scenarios with each other and against the base case scenario of no changes to management arrangements.

Management options were defined as either:

- adjustments to existing management instruments to further constrain catch (e.g. shorter recreational fishing season length, reduce bag limit)
- introduction of new management instruments to further constrain catch (e.g. individual seasonal limits for recreational fishers).

The former were considered short-term options. Long-term options were defined as major adjustments to settings of existing management instruments (including adjusting the catch share proportions), and/or the introduction of new management instruments, and/or reduction in the rebuilding rate and ECSRS objective. Alternative management options identified based on the review were further discussed and validated at a workshop between DPIPWE Wild Fisheries Management Branch and IMAS in March 2019.

Management scenarios were defined as combinations of management instruments and settings on the basis that rock lobster fishing by both recreational and commercial fishing activity is currently managed using a range of instruments (e.g. licenses, bag limits, catch caps, ITQs). These could include existing and new management instruments and minor or major adjustments to settings of instruments.

Specific alternative management scenarios were not, however, identified (i.e. the combination of specific instruments and settings were not defined) nor recommended. This is because the feasibility of implementation of various management options in achieving the east coast stock rebuilding target needed to be established before DPIPWE was willing to identify specific alternative management scenarios for evaluation. As such, no analysis of costs and benefits associated with specific alternative management scenarios was undertaken, although types of costs and benefits to be considered should such an analysis occur were identified.

Instead, for the purposes of assessing the feasibility of implementation of management intervention options, broad types of alternative management scenarios were identified, as follows.

- Base case management scenario, defined as: Pursuit of the current rebuilding objective using existing management instruments and settings.

- Types of alternative management scenarios, defined as:
  A. Pursuit of the current rebuilding objective using existing management instruments and adjustments to settings (e.g. further constrain recreational catch using existing instruments).
  B. Pursuit of the current rebuilding objective using existing and additional management instruments and adjustments to settings (e.g. includes formal re-allocation in addition to increased management controls and limits).
  C. Adjustment of the rebuilding objective to a slower rate of rebuild with no change to management instruments and settings.
  D. Adjustment of the rebuilding objective to a slower rate of rebuild along with adjustments to existing management instruments and settings.

Assumptions applied to all management scenarios included:
- recreational catches would increase if no further constraints applied
- commercial catches would be constrained to the commercial catch cap

The base case and alternative management scenario types were explored to an extent through the DCE in which recreational fisher preferences for various choice sets representing combinations of management options were measured. As discussed in the previous section, two specific scenarios were also examined by introducing increasing recreational catches to the Tasmanian Rock Lobster Stock Assessment model in order to consider, firstly; the implications of unrestrained increasing recreational catches on east coast stock rebuilding (the base case management scenario) and, secondly; the impact on the remainder of the Tasmanian rock lobster stock if the overall ECSRZ catch was maintained at target levels by offsetting recreational over-catch with equivalent reductions in the east coast commercial catch cap (alternative management scenario B).

The feasibility of these alternative management options and scenarios was examined using the synthesis and survey methods described in previous sections. Feasibility of alternative management options and scenarios was assumed to be based on the:

- effectiveness of the proposed option at directly constraining catches and therefore supporting achievement of the ECSRS target,
- compliance and fisher behaviour effects which had either a neutral or synergistic effect on the effectiveness of the option or scenario, and
- acceptability of those option/s to fishers (i.e. alignment with preferences) and other stakeholders, and the practicality of implementation.

Therefore, the range of methods were used to investigate recreational and commercial fisher responses to and preferences for existing management instruments and settings as well as alternative management options, and to model the effectiveness of these options in constraining recreational catches and the impact on commercial fleet dynamics.

Table 3. Alternative management instruments and settings available to pursue the objectives of the ECSRS (2018)

Instrument (existing and/or alternative)	**Alternative settings**			**Alternative management scenario**
	Commercial	Recreational	Customary	
Operational fisheries management				
Entry requirements	Limit entry to local East Coast fishers only (priority access)	Limit number of Recreational Licenses issued which permit access to the East Coast	No change	B
Output controls	Split quota into east coast/west coast units and allocate east coast units based on local catch history	Reduce daily bag limit	Reduce daily bag limit	B, D
		Individual seasonal catch limit	Same as recreational	A, B, D
		Maximum seasonal catch limit	Same as recreational	A, B, D
Gear (input) controls	Reduce the maximum number of pots per vessel that can be used on the east coast	n/a	n/a	B
Size limits	Increase minimum size limit	Increase minimum size limit	Increase minimum size limit	A, B, D
Fishing season	n/a	Reduce season length	Reduce season length	A, B, D
Fisheries allocation policy				
Allocated catch share for East Coast (%)	Reduce catch share	Increase catch share	Allowance (not within allocation)	B, D
East Coast Stock Rebuilding Strategy				
Rate of rebuild	Reduce rebuilding rate to accommodate over-catches			C, D

Results

Recreational fisher surveys

Response rates

The phone survey sample of 742 was reduced to 729 once sample loss (disconnected and wrong numbers) was considered (Table 4). Valid survey responses were available from 570 respondents, representing 78% of the net sample. The higher rate of non-response (18%) for the Diary sample (compared to 8% for the Supplementary sample) was due to a high proportion of partially completed interviews (n = 64), a consequence of prioritising completion of the diary survey (Lyle 2018) meaning that some interviews were deliberately truncated.

Table 4. Response analysis by sample type for the phone survey of recreational rock lobster fishers.
* Non-response includes refusals and partially completed surveys.

	Diary sample	Supplementary sample	Combined
Gross sample	443	299	742
Sample loss	1	12	13
Net sample	442	287	729
Response	334	236	570
Non-response*	80	24	104
No contact	28	27	55
% response	75.6	82.2	78.2

A total of 307 phone survey respondents indicated a willingness to participate in the follow-up DCE survey, of whom 156 provided responses with 143 valid and suitable for analysis (Table 5). This represented a response rate of about 47%, with similar response rates for both on-line and mail survey options.

Table 5. Response profile by survey method for the follow-up DCE survey.
* Non-valid responses include those that involved "protest votes" to each of the management choices options or had obviously not understood the questionnaire.

	On-line	Mail	Total
Potential sample	203	104	307
Valid response	96	47	143
Non-valid response*	9	4	13
No response	*98*	*53*	*151*
% response	47.3	45.2	46.6

Respondent profile

The phone survey sample was dominated by males (91%) with respondents ranging in age from 18 to 88 years, for an average age of about 50 years (Table 6). Both average years of experience recreational fishing and average days spent recreational fishing in a year were approximately double the years of rock lobster fishing experience and days spent fishing for rock lobster each year. For individual respondents, the proportion of "normal" days spent fishing in a year that involved or included fishing for rock lobster was on average 50.2% (SD 29.7%).

Interestingly, reported days spent lobster fishing during 2017/18 (average 6.8 days) was effectively half the level "normally" fished for lobster (average 13.7 days), and compared with the 2017/18 phone-diary survey estimate of 4.5 days (or 6.0 for active fishers[11]) (Lyle 2018). The average reported harvest of 7.7 lobster per fisher in 2017/18 compared with 4.2 (6.4 for active fishers) based on the phone-diary survey (Lyle 2018). Differences between estimates may be explained by differences in survey methods. Specifically, catch and effort estimates for the supplementary sample relate to the full rock lobster fishing season and are based on respondent recall. By contrast, the phone-diary survey estimates relate to the period November to April and, being based on diary records are less impacted by recall biases (Lyle 2018).

Table 6. Profiling characteristics for phone survey respondents.
SD is standard deviation.

	Mean	SD	Median	Range
Age	49.7	15.0	50	18-88
% Males	90.9			
Years recreational fishing	31.4	16.7	30	0-75
Years lobster fishing	18.7	15.6	15	0-65
Av. days recreational fishing	29.6	27.3	24	0-300
Av. days lobster fishing	13.7	15.6	10	0-100
Days lobster fishing (2017/18)	6.8	11.0	3	0-100
Lobster catch (2017/18)	7.7	10.0	5	0-100

In total, 85.3% of respondents indicated that they normally fished for rock lobster off the East Coast (between Eddystone Point to Whale Head/South East Cape), effectively within the ECSRZ. In addition, 14.7% (83) fished for lobster off the North Coast (Eddystone Point to Woolnorth, including the Bass Strait Islands) while 12.5% (71) fished off the West Coast (Woolnorth to Whale Head/South East Cape). A small proportion (9.4%) of respondents reported that they usually fished in two regions, while less than 2% indicated that they usually fished in all three coastal regions. The especially high representation of respondents who fished the East Coast is a consequence of sample design, with higher selection probabilities applied to licence holders residing in localities that border the east coast.

Participation in other fishing activities

Respondents were asked to indicate the types of fishing other than for rock lobster that they had participated in during the previous 12 months. Overall, 96% (541) of respondents did at least some form of recreational fishing, with line fishing in coastal and estuarine waters for species such as flathead, Australian salmon and calamari the dominant activity (89% of respondents) (Fig. 11). Dive harvesting of scallops and abalone (37%), game fishing (35%) and deep-water bottom fishing (striped trumpeter, blue-eye trevalla) (34%) were of secondary importance. Only four respondents (<1%) indicated that rock lobster was their sole fishing activity during 2017/18.

[11] Active fishers refer to those rock lobster licence-holders who reported fishing for rock lobster during 2017/18. Typically, a proportion of licence holders do not end up fishing for rock lobster within the licencing period.

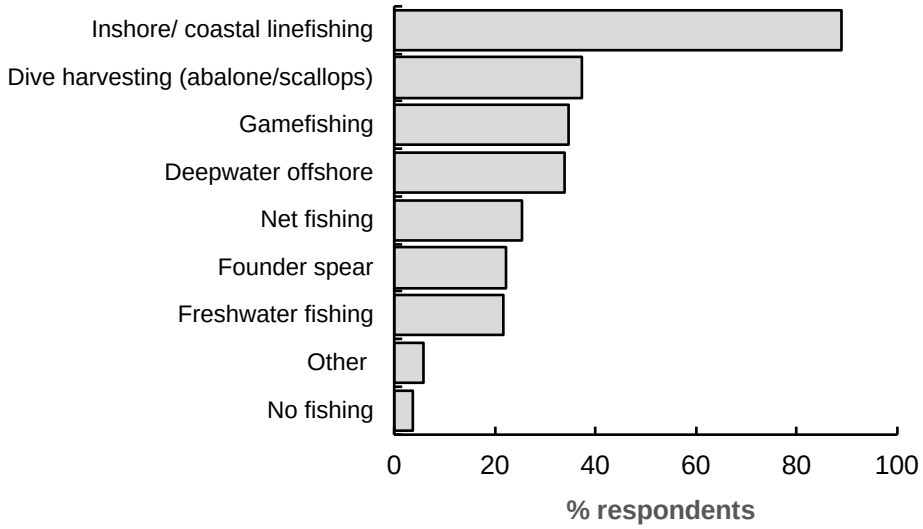


Fig. 11. Percentage of respondents indicating that they had participated in selected non-lobster fishing activities during the twelve months prior to interview

Social importance

Overall 42% of respondents indicated that recreational fishing was their most important outdoor activity, however, when asked about the relative importance of lobster fishing compared to other types of fishing, just 19% regarded it as their most important fishing activity (Table 7). This latter finding is not unexpected since most lobster fishers engage in a range of fishing activities, with lobster fishing effort typically averaging about half of the total days spent fishing (refer previous sections).

When the relative importance attributed to fishing and to rock lobster fishing was considered for the respondent groupings it emerged that fishing mode and avidity were significant factors for fishing in general but not in terms of the relative importance attributed to rock lobster fishing when compared to other types of fishing (Table 8). Post-hoc pair-wise comparisons revealed that dive-only and the least avid (0-5 days) fisher groups were significantly more likely to rank fishing less highly than other fishing modes or more avid (11-20 days and 20+ days) fishers, respectively (Fig. 12). In a previous study, Frijlink and Lyle (2010) obtained similar results in terms of the relative importance attributed to fishing and to lobster fishing when compared with other outdoor and other types of fishing activities (39% and 19%, respectively as most important activity). They did, however, establish that dive-only licence holders were significantly more likely to rate fishing (diving) for rock lobster as their most important fishing activity (24.5%) when compared with pot (16.4%) or multi-method (18.3%) fishers which is in apparent contrast to the current findings.

Table 7. Stated importance of fishing and fishing for rock lobster

	Fishing compared to other outdoor activities		**Lobster fishing compared to other types of fishing**	
	No. responses	%	No. responses	%
Most important	234	41.8	107	19.2
Second most important	78	13.9	129	23.2
One of many	248	44.3	320	57.6
Total respondents	560		556	

Table 8. Kruskal-Wallis test for the effect of respondent grouping factors on the importance of recreational fishing.

For this analysis scoring was based on 1= most important, 2 = second most important, 3 = one of many.

	Fishing mode			Avidity		
Statement	**$\chi 2$**	**df**	***p***	**$\chi 2$**	**df**	***p***
Fishing compared to other outdoor activities	12.75	2	0.002	19.68	3	0.000
Lobster fishing compared to other types of fishing	2.08	2	0.353	7.78	3	0.051

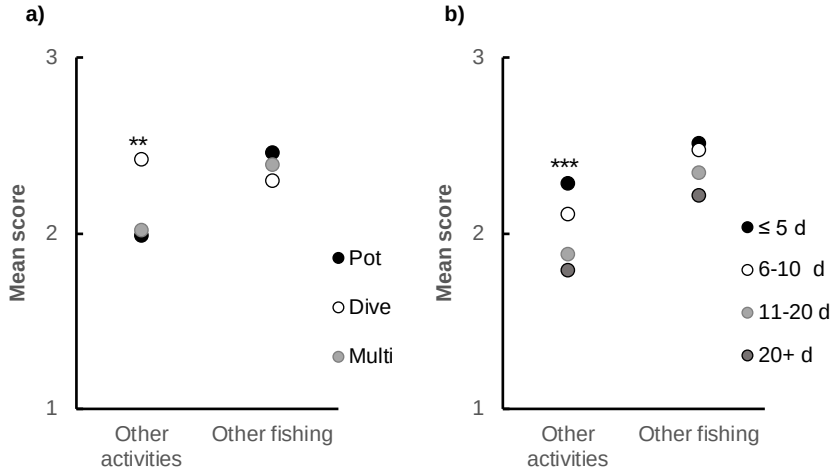


Fig. 12. Mean importance scores for fishing compared with other outdoor activities and rock lobster fishing compared with other types of fishing based on a) fishing mode and b) avidity groupings. Significant differences (Kruskal-Wallis test) are indicated: ** p<0.01; ***p<0.001. Scoring is based on 1- most important, 2- second most important, 3 – one of many.

Motivation and attitudes to rock lobster fishing

Respondents were presented with a series of statements about rock lobster and were asked for their level of agreement on a 4-point scale, from 1 = strongly agree to 4 = strongly disagree. Respondents who indicated that they were either unsure or the statement was not relevant to their situation have been excluded from the analysis.

The strongest agreement (lowest mean score) was for the statement "being able to eat lobster I've caught is an important social occasion", followed by "an unexpected closure of the lobster fishery due to high biotoxin levels wouldn't influence my decision to still go fishing or diving for other species in that area" and "I would still undertake a similar number of fishing trips to the East Coast even if I couldn't go fishing or diving for lobster there" (Table 9). In each case between 78-85% respondents indicated at least mild agreement with the statements. Two thirds of respondents indicated agreement with the statement "fishing or diving for lobster is one of the most satisfying things that I do", reinforcing the social value attached to the activity.

By contrast, greatest disagreement (highest mean scores) was expressed to the statements "I consider myself an expert at catching lobster" and "if I couldn't go fishing or diving for lobster, I'm not sure what I would do", in these instances 78 and 74% of respondents, respectively disagreed with the statement. Two statements, "when I go lobster fishing I am not satisfied unless I catch at least one lobster" and "if the daily bag limit was reduced to one lobster I probably wouldn't bother fishing for lobster" elicited polarised responses, with an equal split between respondents expressing agreement and disagreement with the statements.

Significant differences in the levels of agreement were observed between respondent groups for several statements (Table 9, Fig. 13). For instance, both grouping categories influenced the responses three of the statements – "fishing or diving for lobster is one of the most satisfying things I do", "I consider myself to be an expert at catching lobster" and "if I couldn't go lobster fishing where I usually go because of biotoxin closures I would travel to another zone to fish for lobster". In the first two statements pot fishers and the least avid group (0-5 days) had significantly higher scores (less agreement) than multi-method and the most avid fisher groups (11-20 and 20+ days), respectively. In relation to willingness travel to other zones, mean scores for pot fishers and the most avid fisher group (20+days), were higher than dive-only and multi-method groups and the two intermediate avidity groups (6-10 and 11-20 days), respectively. Dive-only fishers expressed significantly greater disagreement than the other groups to the statement "if the daily bag limit was reduced to one lobster I probably wouldn't bother fishing for lobster". The least avid group indicated greater disagreement to the statement "if I couldn't go fishing or diving for lobster, I'm not sure what I would do" but were more likely to agree with the statement "I would rather catch one large lobster than two just legal sized lobster" than the two highest avidity groups. While there is heterogeneity in group responses, it is worth highlighting that pot-only licence holders appeared less favourable in terms of their willingness to relocate to other regions if the area that they usually fished was subject to biotoxin closures or adapt to or accept a reduction in bag limit (i.e. more likely to indicate they would not both fishing for lobster if the bag limit was further reduced) than the other fisher groups.

The consumptive nature of the fishery was evident in the strong preference (mostly) for the personal consumption of fresh (90% of respondents) rather than frozen (8%) lobsters (Fig. 14). About half of all respondents did, however, indicate that they at least occasionally gave lobsters away to other households or families. Exchanging lobsters for other products or services was reported as being uncommon, which is not unexpected since bartering of recreationally caught fish is not legal in Tasmania.

Collectively, these findings not only highlight the social importance attributed to fishing for and consuming rock lobster but also emphasize that lobster fishing is typically one of a range of recreational fishing activities undertaken and that most fishers would substitute fishing for lobster with other fishing activities if the former was not an available option. This 'flexibility' does not, however, imply that recreational fishers would be ambivalent in their reaction to loss or reduced opportunity to fish for rock lobster.

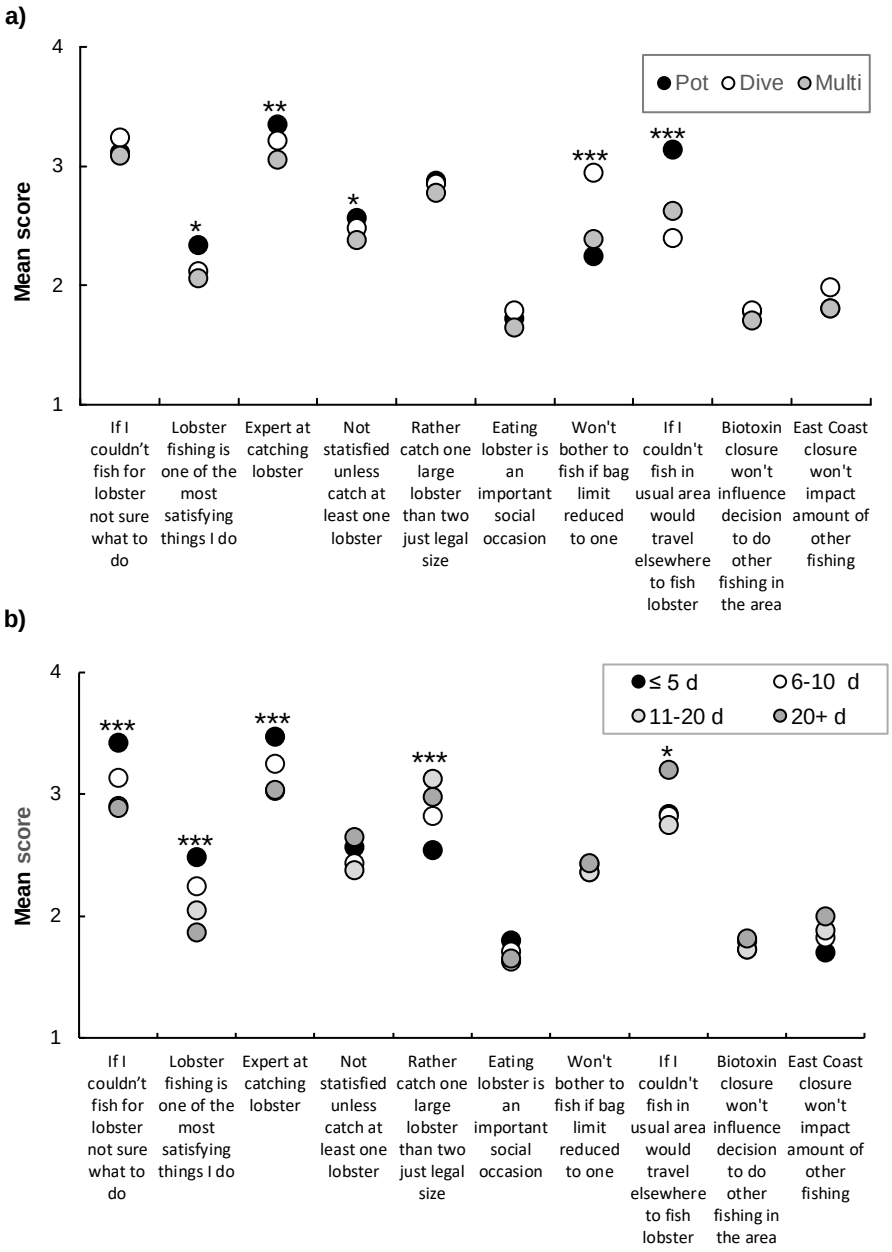


Fig. 13. Mean agreement scores for statements about lobster fishing based on a) fishing mode and b) avidity groupings. Significant differences (Kruskal-Wallis test) are indicated: * p< 0.05; ** p<0.01; ***p<0.001. Scoring is based on 1- strongly agree, 2- mildly agree, 3 – mildly disagree, 4 – strongly disagree.

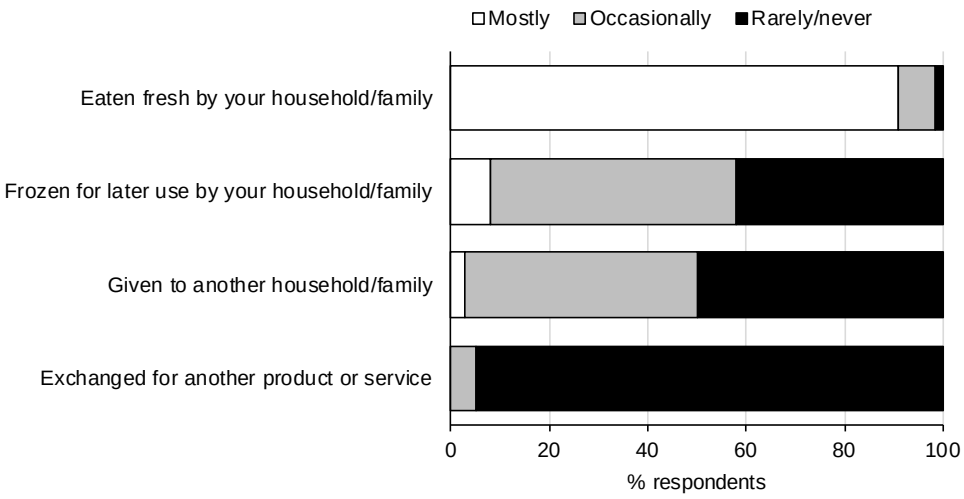


Fig. 14. Reported use of rock lobsters retained by recreational fishers. Depending on question, respondent numbers ranged between 556-558.

Table 9. Mean and standard deviation (SD) agreement scores based on statements about rock lobster, results of Kruskal-Wallis tests for the influence of respondent grouping factors on scores are also presented.

Agreement scores were coded as: 1- strongly agree, 2- mildly agree, 3 – mildly disagree, 4 – strongly disagree.

				Fishing mode			Avidity		
Statement	**No.**	**Mean**	**SD**	**$\chi 2$**	**df**	***p***	**$\chi 2$**	**df**	***p***
If I couldn't go fishing or diving for lobster I'm not sure what I would do	560	3.12	1.04	2.33	2	0.311	18.10	3	0.000
Fishing or diving for lobster is one of the most satisfying things I do	563	2.21	1.08	7.97	2	0.019	25.41	3	0.000
I consider myself to be expert at catching lobster	561	3.22	1.01	9.43	2	0.009	18.47	3	0.000
When I go lobster fishing I am not satisfied unless I catch at least one lobster	558	2.49	1.16	2.82	2	0.245	3.88	3	0.274
I would rather catch one large lobster than two just legal sized lobster	559	2.84	1.16	0.77	2	0.681	21.74	3	0.000
Being able to eat lobster I've caught is an important social occasion	558	1.70	0.84	1.07	2	0.587	3.03	3	0.387
If the daily bag limit was reduced to one lobster, I probably wouldn't bother fishing for lobster	562	2.39	1.23	19.57	2	0.000	0.48	3	0.923
If I couldn't go lobster fishing where I usually go because of biotoxin closures I would travel to another zone to fish for lobster	543	2.86	1.14	35.73	2	0.000	9.40	3	0.024
An unexpected closure of the lobster fishery due to high biotoxin levels wouldn't influence my decision to still go fishing or diving for other species in that area	550	1.76	0.97	1.04	2	0.594	0.86	3	0.834
I would still undertake a similar number of fishing trips to the East Coast even if I couldn't go fishing for diving for lobster there.	486	1.83	1.04	1.57	2	0.456	2.18	3	0.537

Recreational fisher management preferences

Phone survey

Respondents were briefly informed about the objectives of the east coast stock rebuilding strategy, current management arrangements (2017/18) and the need to constrain recreational catches to the notional east coast catch limit. They were then presented with six hypothetical management options intended to assist in restricting recreational catches and asked whether they considered each measure would be effective and whether they were generally supportive of the measure if applied to the Eastern Region.

The management option that was rated as effective and attracted the support from the greatest majority of respondents (>74%) was a maximum seasonal catch limit for each licence-holder (Table 10). When asked as a follow up question, "How many lobsters would you consider as acceptable for such a seasonal catch limit?", the median response (n = 447 respondents) was 20 lobster per season (mean = 25.9). There was, however, considerable variability in acceptable levels, with 16% of respondents recommending limits of 40 or more and 2% recommending at least 100 lobster per season. In comparison, a survey of rock lobster fishers conducted in 2015 yielded slightly lower support (63%) for a seasonal catch limit but with substantially higher expectations in terms of acceptable east coast catch limits, namely a median of 30 lobster per season (mean = 37.3) (Lyle and Tracey 2016a). The increased support and lower seasonal catch "expectation" in the current study may be indicative of growing recognition by the recreational sector of the need to constrain and manage catches to facilitate stock recovery.

The only other options that attracted majority (~55%) support were an increase in the minimum size limit and reduction in the commercial catch allowance to offset any over-catch by the recreational sector. Willingness to pay a small fee to reduce the commercial catch allowance (for example as a buy-back of catch quota) was less forthcoming; 42% of respondents (n = 498) expressed willingness to contribute; 46% indicated that they would not be prepared to pay extra while 13% were unsure.

Limiting recreational licence numbers was rated as the least effective (19%) and was the least supported (9%) of the management options. While 40% of respondents considered that a further reduction in the bag limit (to one lobster per day) would be effective, this option attracted the second lowest level of support (29%).

Although just over half of respondents indicated that further reduction in the eastern season length would be effective, less than half supported this measure. It was noted that the current season (2017/18) was about 24 weeks and when asked "… what do you think would be the minimum acceptable season length?" the median response (n = 435) was 18 weeks (mean 19 weeks). Overall, 20% of respondents proposed maintaining the current season length while 3% recommended that it should be increased.

For each management measure a small proportion of respondents indicated that they were unsure about the effectiveness or whether they would support the measure (ranging 2-10% across different management tools). The lowest proportion of unsure responses was for a reduction in daily bag limit, suggesting high certainty, whereas 10% of respondents were unsure for a reduction of commercial catch allowance, suggesting low certainty around this management measure.

There was heterogeneity in the level of support (unsure responses removed) for several of the management measures based on respondent groupings (Fig. 15). Dive-only licence holders indicated significantly higher support for a reduction in the bag limit ($\chi^2 = 15.20$, df = 2, p = 0.0005) and an increase in size limit ($\chi^2 = 6.75$, df = 2, p = 0.034) than either of the other licence groups. When categorised by avidity, it emerged that the least avid fisher group were more supportive of a reduction in the bag limit than the other groups ($\chi^2 = 10.61$, df = 3, p = 0.014), whereas the most avid group was least

supportive of any further reductions in season length ($\chi^2 = 8.67$, df = 3, p = 0.034). Differences in support for the other management measures were not significant based on the grouping factors.

Greater support from dive-only licence holders for a bag limit reduction is consistent with this group's general disagreement that any such a reduction would impact on their willingness to continue to target rock lobster (Fig. 15). On the other hand, the strong opposition to this measure from pot-only and multi-method licence groups may be linked to lower success rates; typically, only half of all recreational pot-sets produce a legal-sized lobster, with average catch rates being less than one lobster per pot-day (Lyle 2018). As such, a reduction in the bag limit may be perceived as both unnecessary and excessive in the context of impact on those rare occasions that two legal-sized lobsters are captured by potters. The higher support from divers for a size limit increase is consistent with the fact that they can and do actively select for larger lobsters (e.g. Lyle 2018), any increase in size limit would therefore have limited impact for this group. By contrast, pots represent a passive fishing method in terms of the size selection and thus an increase in minimum size limit would mean more lobster would be released and hence catch rates impacted.

Table 10. Response summary to hypothetical management options intended to constrain recreational rock lobster catches to meet rebuilding targets.

		Effective		Support	
Management option	**Response**	**No.**	**%**	**No.**	**%**
Reduce the daily bag limit to one per day	Yes	204	40.6	143	28.7
	No/Not really	288	57.4	344	68.9
	Unsure	10	2.0	12	2.4
Increase the minimum size limit, meaning more of the catch is released	Yes	306	60.8	274	54.8
	No/Not really	170	33.8	204	40.8
	Unsure	27	5.4	22	4.4
Further reduce the length of the season (in the Eastern Region)	Yes	272	54.3	244	48.9
	No/Not really	205	40.9	235	47.1
	Unsure	24	4.8	20	4.0
Introduce a maximum East Coast seasonal catch limit for each licence-holder	Yes	380	75.7	369	73.9
	No/Not really	107	21.3	114	22.8
	Unsure	15	3.0	16	3.2
Limit the number of licences that have access to the Eastern Region for lobster	Yes	83	16.6	45	9.0
	No/Not really	388	77.6	425	85.3
	Unsure	29	5.8	28	5.6
Reduce the commercial catch allowance to offset any increase in recreational catches	Yes	291	58.1	266	54.6
	No/Not really	160	31.9	175	35.9
	Unsure	50	10.0	46	9.4

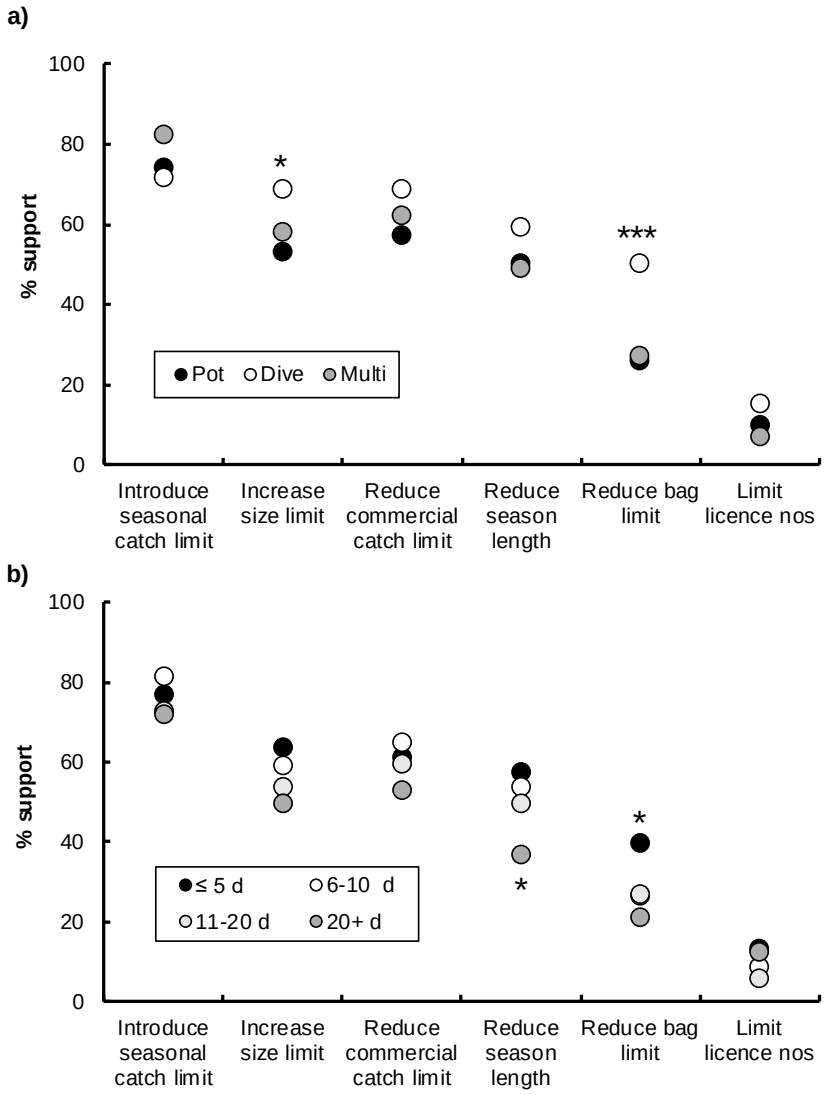


Fig. 15. Support (unsure responses removed) for six management options based on a) licence and b) avidity groupings. Significant differences (chi squared test of independence) are indicated * $p < 0.05$; ***$p<0.001$.

Discrete choice experiment

The results of the choice experiment showed that all management tools have positive coefficients which is expected as fishers on average prefer less regulation, however, only a reduction of bag limit and season length were significant at the 5% level and introducing a maximum season catch was significant at the 10% level (Fig. 16). An increased size limit for females and increased penalties were not significant for the whole sample.

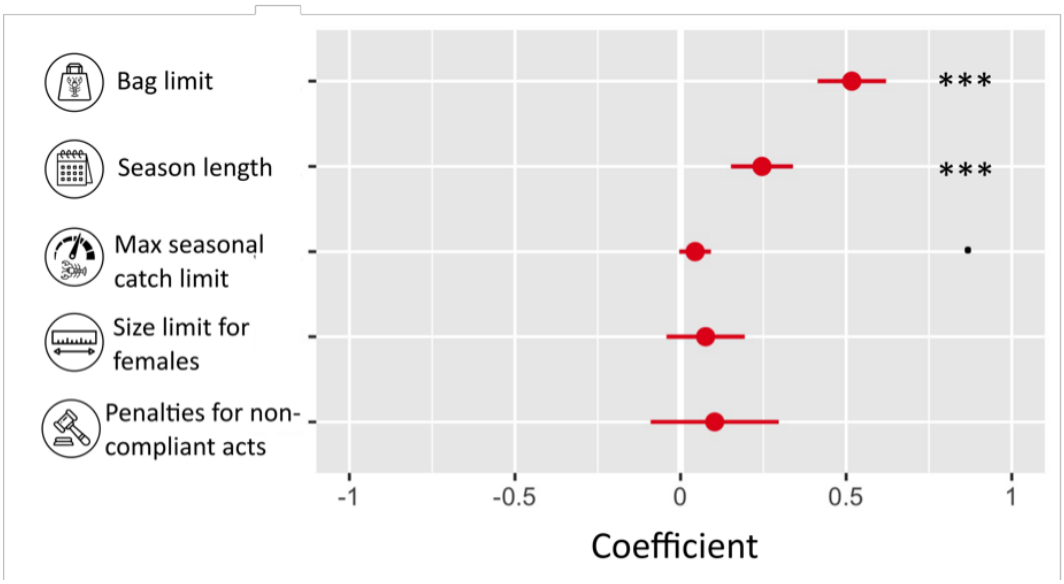


Fig. 16. Conditional logit model results of the choice experiment responses for all respondents. Error bars indicate standard error (. p< 0.1; * p< 0.05; ** p< 0.01 *** p< 0.001). See Appendix 7 for detailed regression results.

When the model was estimated based on respondent fishing mode, bag limit had a significant coefficient for all fisher groups (Fig. 17a), meaning that there is no heterogeneity in preferences towards the bag limit. The regression, however, showed heterogeneous preferences for season length and maximum seasonal catch limit. The coefficient for season length was significant and positive for pot-only and multi-method fishers, but not for divers. Likewise, the coefficient for maximum seasonal catch was only significant for divers and pot-only fishers (the latter only at the 10% level). All other management options; increase in size limit and increase in penalties were not significant for all fisher groups.

Across all levels of avidity, bag limit and an increase in season length were the management tools which have a significantly positive coefficient (Fig 17b). A maximum seasonal catch limit was significant for low avid fishers only. An increase in size limits for females was only significant for high avid fishers while an increase in penalties was not significant for all avidity groups.

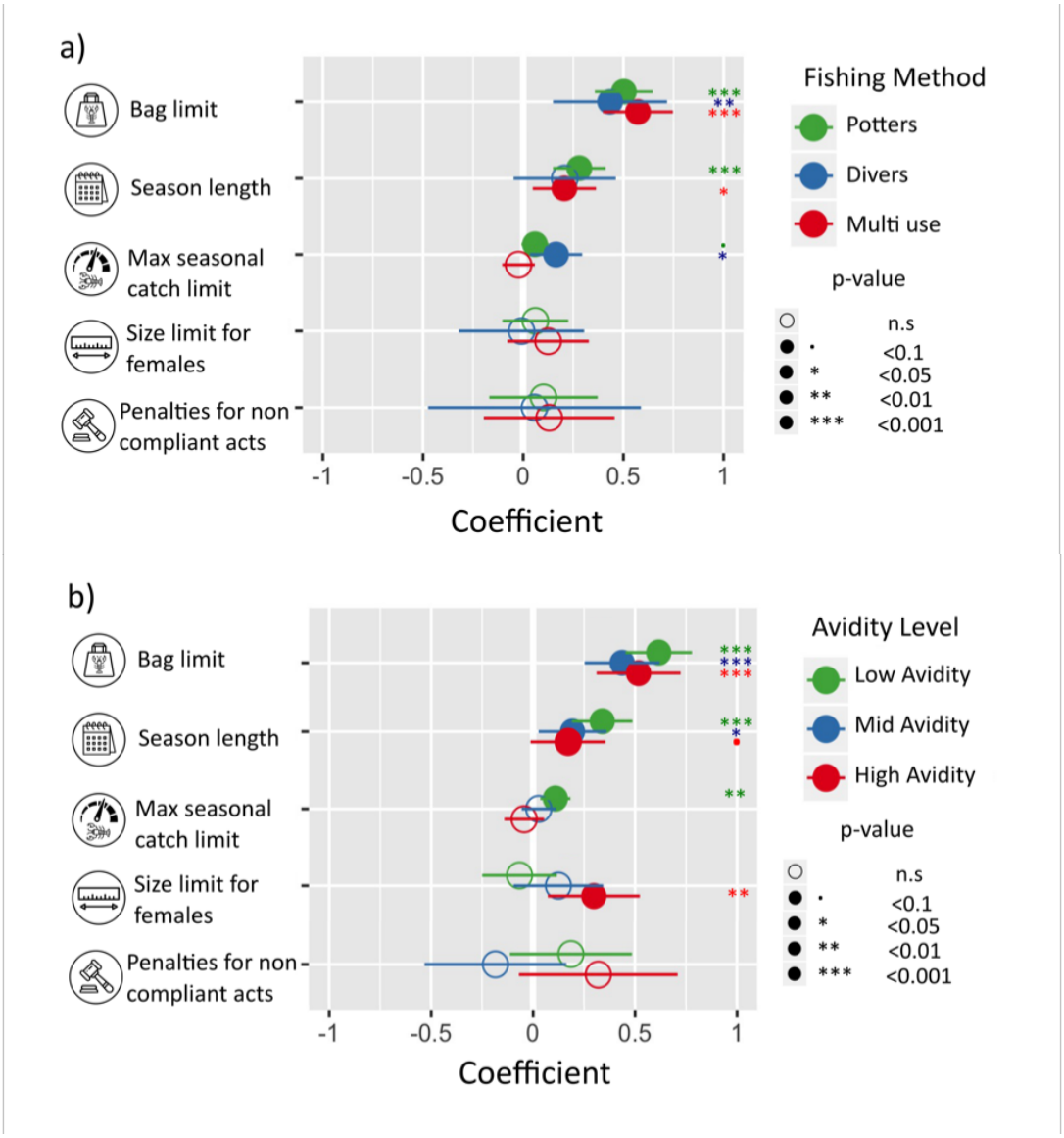


Fig. 17. Conditional logit model results of the choice experiment responses for a) fishing mode and b) avidity groupings. Error bars indicate standard error (**.** p< 0.1; * p< 0.05; ** p< 0.01 *** p< 0.001). Appendix 6 for detailed regression results.

Management trade-offs

The trade-offs fishers are willing to make for a reduction of bag limit by one lobster is reported in Fig. 18. The results are presented for the full sample of fishers, as well as for fishing mode and avidity level groups. Fishers were on average willing to accept a decrease in the bag limit by one lobster if the season length was increased by 3.5 weeks (Fig. 18a) This trade-off ranges from the highest for potters (4.5 weeks) and low avid fishers (4.4 weeks) to the lowest for multi-method fishers (2.9 weeks) and high avid fishers (2.6 weeks). This result suggests that the relative value (utility) of season length is higher for potters and low avid fishers than the other groups.

There was greater variability across the different groups in the trade-offs for the other management tools. In particular, trade-offs for a maximum seasonal catch was highly variable across groups, being highest at 1.5 lobsters per season for divers and close to zero for multi-method fishers (Fig. 18b). This indicates that divers would be most affected by the introduction of the maximum seasonal catch limit. For the size limit option, the trade-off was highest for high avid fishers who were, on average willing to accept a decrease in the bag limit by one lobster if the size limit for females was decreased by 2.9 cm. Finally, the trade-off for penalties was relatively consistent across groups (decrease of around 10%) for

all but the mid- and high-avid fishers. The former were willing to trade-off a decrease in bag limit for an increase in penalties whereas from high-avid fishers the trade-off was assessed as a reduction in penalties by more than 30%.

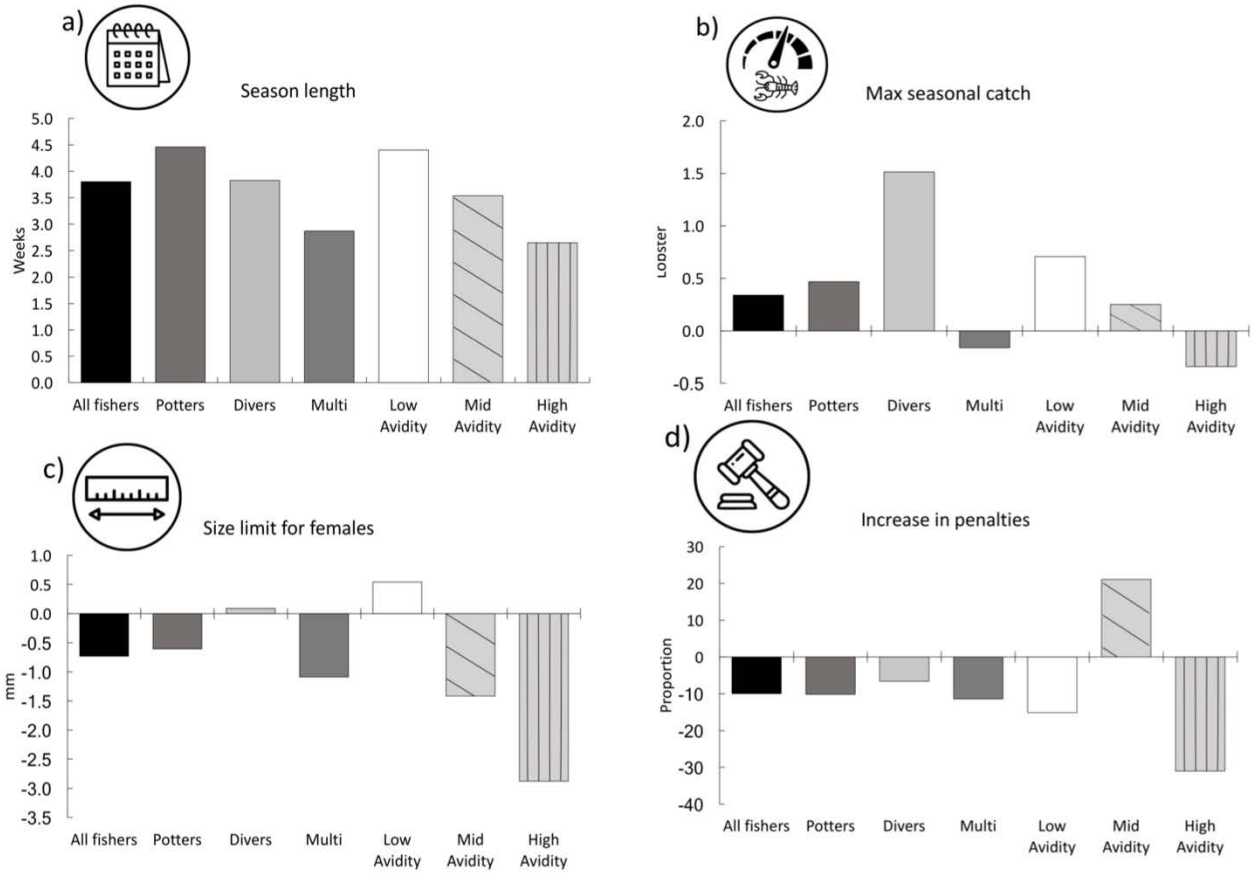


Fig. 18. Trade-offs fishers are willing to make between a reduction in bag limit by one lobster and a change in a) season length, b) maximum seasonal catch, c) minimum size limit for females and d) penalties for non-compliant acts.

Recreational fisher compliance with regulations

The effectiveness of rules and regulations in achieving management objectives is diminished by non-compliant behaviour from fishers. It has been suggested that the magnitude of non-compliance will be influenced by a combination of the perceived risk of being detected and the severity of the penalties (Kuperan & Sutinen 1998, cited in MacKenzie and Cox 2013). Although quantifying the impact and extent of non-compliance in fisheries is challenging, perceptions from fishers can provide insight into the probable magnitude of the issue.

Phone survey

Phone survey respondents were asked whether they had been inspected by the Marine Police (on water and/or on land) whilst fishing for rock lobster during the 2017/18 season. Overall 23.7% (out of 393 respondents) indicated that they had been inspected at least once during the season, with the probability of inspection increasing with number of days fished, such that half of those who had fished for more than 20 days indicated that they had been inspected (Fig. 19). Respondents were not, however, asked whether they considered that there was enough policing to effectively deter non-compliant behaviour although the lack of enforcement was a relatively common theme in general comments about the

fishery. Previous recreational surveys have obtained similar results, with between 20% (2015/16) and 34% (2014/15) of Tasmania fishers reporting interactions with Marine Police while fishing for rock lobster (Lyle and Tracey 2016b, 2017, 2018).

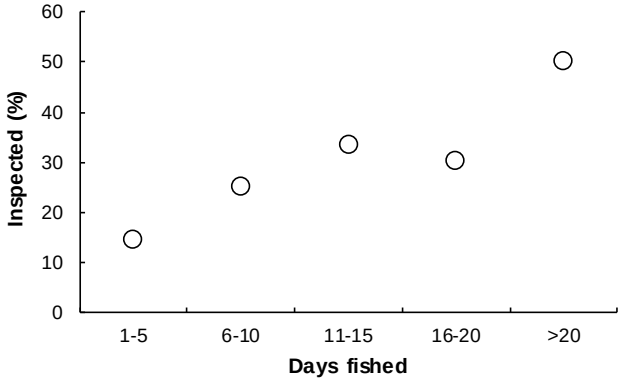


Fig. 19. Relationship between days fished for rock lobster during 2017/18 and proportion of fishers inspected by the marine police

Of six examples of non-compliant activities presented to respondents, pulling of other fisher's gear and stealing the catch followed by catching lobsters for other licensed fishers had the lowest mean scores (i.e. indicating more common activities), with most respondents (> 52%) suggesting that these behaviours were at least quite common forms of non-compliance (Table 11). Exceeding the daily bag limit was perceived to be at least quite common by 40% of respondents whereas the retention of undersized lobster, out of season and/or unlicensed fishing for lobster were considered not common by most (> 70%) respondents.

Table 11. Opinions about non-compliance with regulations

Scores were coded as: 1- very common, 2- quite common, 3 - not very common, 4 - not at all common. Unsure and missing responses have been omitted from the analysis. No. is number of respondents.

Statement	No.	Mean	% very or quite common
Pulling other fisher's gear and stealing their catch	541	2.33	57.9
Catching lobsters for other licence-holders in the fishing party	523	2.58	52.4
Retaining more than the daily bag limit	532	2.80	40.2
Retaining undersized lobster	528	3.04	28.8
Out of season fishing for lobster	504	3.28	15.9
Fishing for lobsters without a licence	513	3.40	15.4

DCE survey

Attitudes and motivations to compliance were also canvassed as part of the DCE questionnaire, explored as factors influencing personal behaviour and the behaviour and motivation of others. Individual respondents overwhelmingly agreed that they felt obliged to obey fisheries regulations, with the penalties, disapproval of friends and family, and to a lesser extent the disapproval of other people, of being caught representing important motivators (Table 12). Respondents were, however, divided in relation to whether penalties for breaches of the fisheries regulations or the likelihood of being caught were sufficient to be effective as deterrents for non-compliance. Nonetheless, there was low tolerance for fishers who exceed the bag limit, with most respondents (87%) agreeing with the statement that

fishers who did so do not care about conservation, and least agreement (and lowest score of 3.1) for the suggestion that it is reasonable for those who only fish a few days a year to occasionally keep one or two extra rock lobster. Approximately two-thirds of respondents agreed that the current bag limit allowed a "fair or equal" share of the benefits and resources on the east coast, indicating a general acceptance by most recreational fishers of the current bag limit, despite the recent (2015) reduction in the limit (from 3 to 2 lobster). Fewer than 40% of respondents agreed with the statement that extra catches taken by recreational fishers were unlikely to have a detectable impact on the lobster population. Conversely 53% disagreed with this statement, implying that a greater proportion of recreational fishers recognise that catches by the sector, albeit lower than commercial catches, contribute to the overall fishing pressure on the rock lobster stocks.

Respondents were also asked to estimate the proportion of recreational fishers they considered may have exceeded daily bag, possession and/or boat limits during 2017/18. Individual responses were highly variable but overall mean values for bag and possession limits were similar, 19.3% (SD 20.3%) for bag limit and 19.7% (SD 19.4%) for possession limits. Exceeding the boat limit was perceived to be slightly less common, 15.9% (SD 17.9%), potentially because reaching the limit is a relatively uncommon occurrence. Interestingly, 31% of respondents acknowledged that they knew of fishers who had kept more than the bag limit in the last 12 months (Table 12).

Collectively these data suggest that recreational fishers recognise that non-compliance is an issue within the sector, possibly exacerbated by recently imposed catch reductions, even though the financial and personal social consequences of being caught provide a strong incentive for compliance.

Table 12. Agreement with statements about compliance behaviour by respondents to the DCE survey.
Agreement scores were coded as: 1- strongly agree, 2- mildly agree, 3 - mildly disagree, 4 - strongly disagree.
+ 10-20% of respondents indicated that they did not know; ++ >20% indicated that they did not know.

Statement	No.	Mean	% agree
I feel obliged to obey the fisheries regulation.	152	1.4	97.4
The risk of getting my boat, fishing equipment, or other property confiscated would prevent me from keeping more than the bag limit.	152	1.4	93.4
The risk of being fined would prevent me from keeping more than the bag limit.	151	1.6	88.1
I care whether my friends and family would disapprove if I kept more than the bag limit.	151	1.7	87.4
The social shame of being caught would prevent me from keeping more than the bag limit.	152	1.8	75.0
I care whether people I don't know would disapprove of me if I kept more than the bag limit.	150	1.9	77.3
Fishers who keep more than the bag limit do not care about conservation.+	153	1.6	86.9
Fishers who keep more than the bag limit do not believe they will get caught.	153	1.9	71.2
The current bag limit allows everyone a "fair or equal share" of the benefits and resources available on the East Coast of Tasmania.	153	2.1	68.6
Current fines and penalties for fisheries breaches are not high enough to be a real deterrent.+	152	2.4	45.4
The chance of being caught with more than the possession limit is so small that it is not much of a deterrent.	152	2.4	46.7
Any extra catch taken by recreational fishers is unlikely to have a detectable impact on the lobster populations, compared with the commercial fishery	153	2.6	39.9
I know some fishers who have kept more than the bag limit in the last 12 months.++	153	2.7	31.4
Fishers who keep more than the bag limit do so as an act of protest. ++	152	3.0	17.1
It is reasonable for fishers who fish a few days a year to keep an extra rock lobster or two on a given day.	152	3.1	19.1

Commercial fisher survey

Respondent profile

A total of 54 valid responses were submitted (37 on-line and 17 by mail). In addition, there were two non-valid responses where the on-line survey had been commenced but no substantive questions answered.

The average age of respondents was 52.1 years (median 52, range 30-71), with an average of 29.2 years (median 30, range 6-53) experience working in the commercial rock lobster industry. Collectively, respondents reported owning 1477 quota units with a further 2071 units leased during the 2017/18 quota year. Extrapolating this as a proportion of total quota holdings is complicated by the fact that, on one hand three respondents did not provide information about quota holdings, while on the other hand it is likely that some individual fishing operations may have been represented by multiple respondents, resulting in double counting of quota.

Vessels ranged between 8 and 20 metres in length and were licensed to carry between 30 and 60 pots (mean of 46.7, median 50). Respondents who reported greater reliance on the ECSRZ were more likely to operate from smaller vessels (Fig. 20) and fish out of ports located on the east (Triabunna, Bicheno and St Helens) and south-east (Dunalley, Eaglehawk Neck and Nubeena) coasts (Fig. 21). Several operators fishing out of Hobart and Channel region ports (Margate, Kettering, Woodbridge, Dover and Southport) and from the north coast (Bridport, Stanley, Smithton, Grassy) reported fishing within the ECSRZ, although catches from the region represented a minor component of their total catches. West coast operators (Strahan, Nelson Bay) reported no fishing within the ECSRZ.

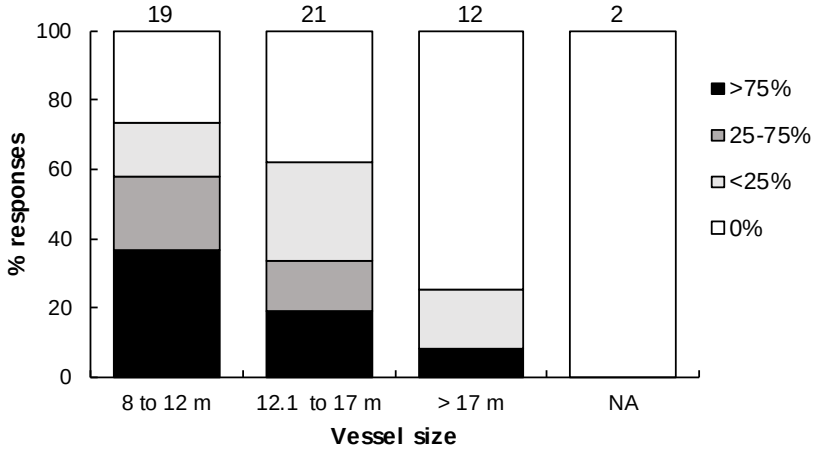


Fig. 20. ECSRZ catch contribution (% of respondent's lobster catch in 2017/18) by vessel size class. Number of respondents by vessel size class is indicated. NA = not answered

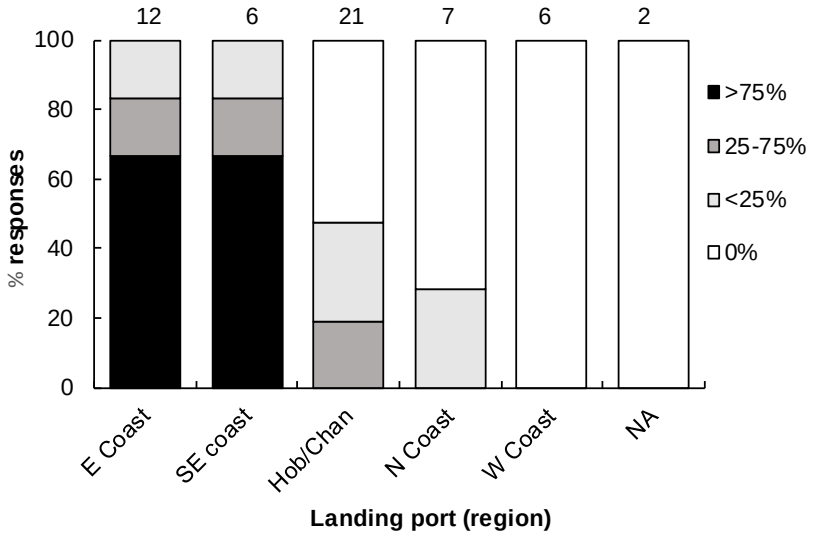


Fig. 21. ECSRZ catch contribution (% of respondent's lobster catch in 2017/18) by landing region (refer text). Number of respondents by main landing region is indicated. NA = not answered

Implications of commercial catch cap being reached

Respondents were informed that as rock lobster stocks rebuild along the east coast it is anticipated that this will attract increased effort from commercial operators resulting in the catch cap being reached earlier each year. When presented with a scenario where the ECSRZ was closed early whilst still holding uncaught quota, most respondents indicated that they would travel to fish in areas that were open rather than lease out uncaught quota or switch to other types of fishing off the east coast. Interestingly, however, 40% of respondents did acknowledge that an early closure of ECSRZ would represent financial hardship for their business (Table 13). As a measure of operational dependence on the ECSRZ, groupings based on reported level of east coast catch did not emerge as a significant factor in the responses.

More than half of those respondents who indicated that they would have difficulty travelling to other zones to fish (n= 16) cited MAST restrictions (e.g. vessel size) as an issue, this was followed by concerns about economic viability, lack of local knowledge in addition to family and health reasons (Fig. 22).

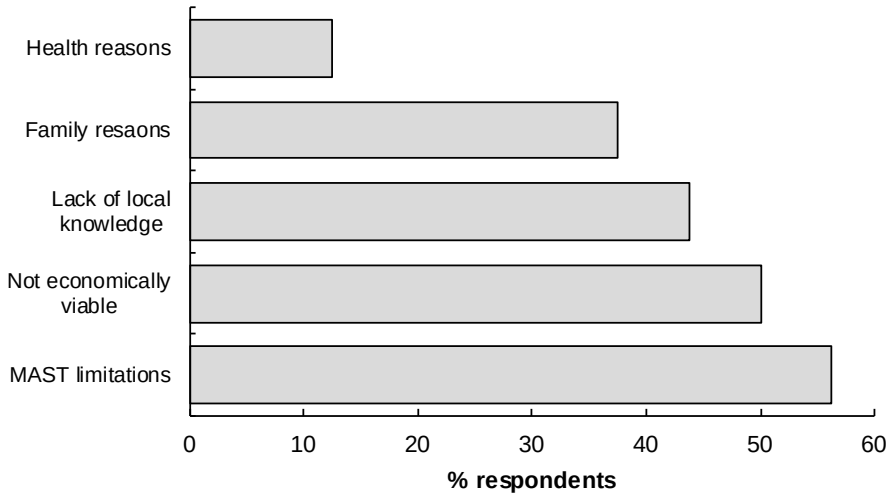


Fig. 22. Factors limiting the ability of respondents to travel and fish in areas outside of the ECSRZ. Respondents who indicated that they were able to travel have been excluded.

Table 13. Response to the question "If I couldn't fish within the east coast stock rebuilding zone because the catch cap had been reached, and I still had quota left, then …."
Chi-squared test of independence based on ECSRZ catch groups (*most >75%, some 1-75%, none 0%).* NA is not relevant or unsure

Statement	Response	No.	%	χ^2	p
I would likely change my home port or where I land my catch to reduce travel to and from open fishing areas.	Strongly agree	10	28.6	5.006	0.082
	Mildly agree	12	34.3		
	Mildly disagree	6	17.1		
	Strongly disagree	7	20.0		
	NA	18			
I would travel to another area to fish my uncaught quota.	Strongly agree	30	75.0	4.912	0.086
	Mildly agree	8	20.0		
	Mildly disagree	0	0.0		
	Strongly disagree	2	5.0		
	NA	14			
I would consider leasing out my uncaught quota.	Strongly agree	4	10.8	4.624	0.099
	Mildly agree	7	18.9		
	Mildly disagree	4	10.8		
	Strongly disagree	22	59.5		
	NA	16			
I would consider other types of fishing (e.g. scalefish) off the east coast.	Strongly agree	2	5.9	3.319	0.190
	Mildly agree	8	23.5		
	Mildly disagree	6	17.6		
	Strongly disagree	18	52.9		
	NA	19			
I would have a hard time maintaining my business.	Strongly agree	12	30.8	1.783	0.410
	Mildly agree	4	10.3		
	Mildly disagree	8	20.5		
	Strongly disagree	15	38.5		
	NA	14			

Implications of east coast catch rate increase

It was noted that east coast catch rates are predicted to increase substantially as rock lobster stocks rebuild which is expected to make the east coast a more profitable region to fish resulting in a "race-to-fish" scenario to take the catch cap. Most respondents (>55%) indicated agreement that they would consider directing more of their fishing effort within the zone as catch rates improved yet also expressed concern over the potential for increased competition with other commercial operators (Table 14). Respondents who currently fished the ECSRZ were significantly more likely to agree that they would feel annoyance if more commercial fishers started fishing in the zone.

Table 14. Agreement with statements about potential fisher behaviour associated with stock rebuilding. Chi-squared test of independence based on ECSRZ catch groups. NA is not relevant or unsure

Statement	Response	No.	%	χ^2	p
If east coast catch rates increased substantially as predicted, then I would consider fishing within the east coast stock rebuilding zone more often and would possibly lease in additional quota.	Strongly agree	10	23.3	0.695	0.706
	Mildly agree	15	34.9		
	Mildly disagree	6	14.0		
	Strongly disagree	12	27.9		
	NA	11			
I would feel annoyed if more commercial fishers started fishing within the east coast stock rebuilding zone.	Strongly agree	12	27.3	8.935	0.011
	Mildly agree	13	29.5		
	Mildly disagree	5	11.4		
	Strongly disagree	14	31.8		
	NA	10			
I am concerned that as stocks continue to improve on the east coast that competition from other commercial operators will put further pressure on the viability of my fishing operation.	Strongly agree	11	25.6	5.155	0.076
	Mildly agree	13	30.2		
	Mildly disagree	4	9.3		
	Strongly disagree	15	34.9		
	NA	11			

Most respondents (n = 29) who fished infrequently, if at all within the ECSRZ[12], identified that improved east coast catch rates followed by declines in other areas would be key factors in making the ECSRZ more attractive region for them to fish (Fig. 23). Proximity of east coast ports to the fishing grounds and increased market prices were less important factors overall.

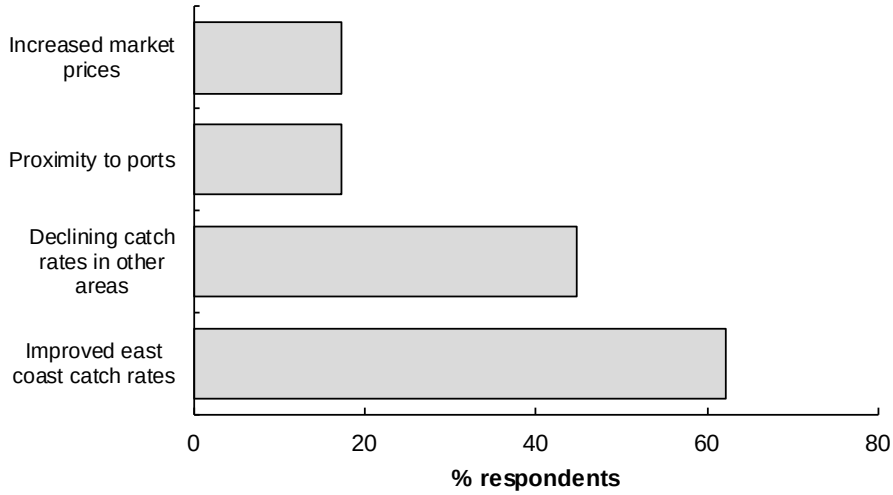


Fig. 23. Key factors that would make fishing within the ECSRZ more attractive for respondents who predominately fished outside of the zone in 2017/18 (i.e. reported less than 25% of their 2017/18 catch from the ECSRZ).

[12] i.e. reported taking < 25% of their 2017/18 catch from the zone

Opinions on ECSRZ management

Current management

A clear majority (88%) of respondents agreed that the implementation of the east coast catch cap was an effective measure for achieving the stock rebuilding goals for the commercial sector (Table 15). Similarly, there was a high level of agreement that the application of the catch cap (as a competitive catch limit) was a fair and equitable measure to manage the commercial fishery, confirming general acceptance and support of the strategy by the commercial sector. While misreporting was considered a minor issue by two-thirds of respondents and over half agreed that there were enough enforcement checks to ensure compliance, more than a quarter indicated concern (strongly disagree) about potential misreporting and lack of compliance checks. Response to the proportional allocation split between commercial and recreational sectors was highly polarised, with just over half of respondents disagreeing that it was fair and equitable. The primary reason for disagreement appeared to be more related to a perception that recreational catches were not known and were not adequately enforced, rather than disagreeing with the proportional catch share allocation. Responses to each of the statements were not influenced by reliance on the ECSRZ.

Table 15. Response to statements about the management of the ECSRZ
Chi-squared test of independence based on comparison between ECSRZ catch groups. NA is not relevant/ unsure

Statement	Response	No.	%	χ^2	p
The application of the east coast catch cap is an effective management measure for achieving the stock rebuilding goals for the commercial fishery.	Strongly agree	26	51.0	4.055	0.132
	Mildly agree	19	37.3		
	Mildly disagree	3	5.9		
	Strongly disagree	3	5.9		
	NA	3			
Application of a catch cap is a fair and equitable way to manage catches taken by the commercial operators.	Strongly agree	27	52.9	1.251	0.535
	Mildly agree	16	31.4		
	Mildly disagree	3	5.9		
	Strongly disagree	5	9.8		
	NA	3			
Misreporting of the zone that catches are taken from is a minor problem within the commercial sector.	Strongly agree	19	45.2	2.175	0.337
	Mildly agree	9	21.4		
	Mildly disagree	3	7.1		
	Strongly disagree	11	26.2		
	NA	12			
There are sufficient marine police checks for commercial unloadings to ensure compliance by commercial operators of the catch cap.	Strongly agree	17	36.2	0.868	0.648
	Mildly agree	10	21.3		
	Mildly disagree	5	10.6		
	Strongly disagree	15	31.9		
	NA	7			
The split of the east coast catch target between commercial (79%) and recreational (21%) sectors is fair and reasonable for both sectors.	Strongly agree	14	28.0	0.102	0.950
	Mildly agree	12	24.0		
	Mildly disagree	6	12.0		
	Strongly disagree	18	36.0		
	NA	4			

Options to reduce intra-sector competition

Overall, there was limited support (15% of 52 respondents) for additional management measures intended to reduce competition within the commercial sector and slow the rate at which the catch cap was reached. Although the majority (62%) were not generally supportive of the need for additional measures, there was a relatively high proportion (21%) of unsure responses suggesting some uncertainty amongst respondents about the need for additional management.

When presented with six hypothetical measures that could slow the rate at which the cap catch was reached and/or reduce competition within the sector almost half (49%) agreed that reducing the maximum number of pots per vessel that could be used on the east coast would be effective (Table 16). Despite this, more than twice as many respondents were not supportive (64%) as were supportive (30%) of the measure. Of the other options, priority access to operators with a proven history of fishing on the east coast while considered effective by 40% of respondents attracted limited overall support (27%). Increasing the minimum size and additional seasonal closures were considered effective by more than a third of respondents (35-36%) but received support from just 22 and 18%, respectively. The option deemed least effective (15%) and least supported (6%) was to split quota into eastern and western units. Interestingly, the greatest uncertainty (> 20% unsure responses) both in terms of effectiveness and support was for an industry-based solution.

When unsure responses are removed, there was considerable variability in the level of support for the individual management measures between groups, in part influenced by relatively small sample sizes (Fig. 24). Not unexpectedly, respondents who indicated that they caught most or at least some of their quota from the ECSRZ were more supportive of measures that either gave them priority access to the available catch cap ($p<0.05$). Although not significant at $\alpha = 0.05$, east coast fishers were more likely to support a reduction in the maximum number of pots that could be used off the east coast and were less supportive of an industry-based solution to reducing competition than operators who fished exclusively outside of the zone.

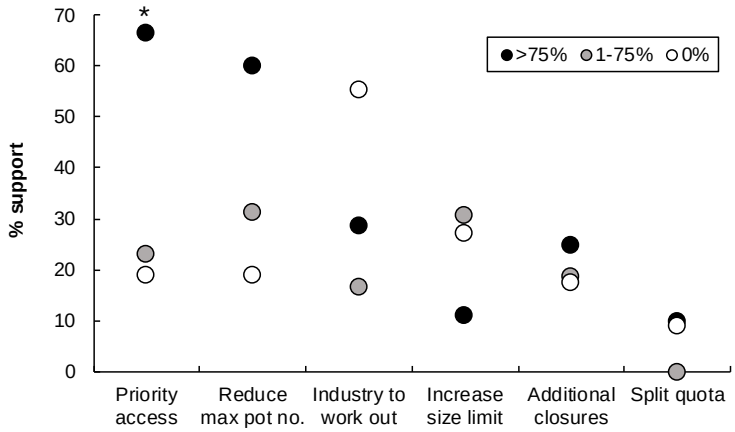


Fig. 24. Support (unsure responses removed) for six management options by ECSRZ catch group (i.e. % of respondent's 2017/18 lobster catch taken from the ECSRZ)
Significant differences (chi squared test of independence) are indicated * $p< 0.05$.

Combined, the survey results indicate that there is heterogeneity in opinions within the commercial sector, and not unexpectedly those operators most affected by the east coast management arrangements expressing greatest concern about the impact on the viability of their operations.

Table 16. Response summary to hypothetical management options intended to slow down the rate at which the east coast catch cap is reached, reducing competition within the commercial sector.
Chi-squared test of independence for management support is based on comparison between ECSRZ catch groups.

	Effective			Support				
Measure		**No.**	**%**		**No.**	**%**	χ^2	**p**
Split quota into east and west quota units	Effective	8	15.7	Yes	3	6.1	1.512	0.758
	Not very	8	15.7	No	44	89.8		
	Not at all	31	60.8	Unsure	2	4.1		
	Unsure	4	7.8					
Increase the minimum size limit	Effective	18	35.3	Yes	11	22.4	1.217	0.544
	Not very	9	17.6	No	33	67.3		
	Not at all	18	35.3	Unsure	5	10.2		
	Unsure	6	11.8					
Additional seasonal closures	Effective	19	36.5	Yes	9	18.4	0.224	0.894
	Not very	8	15.4	No	38	77.6		
	Not at all	21	40.4	Unsure	2	4.1		
	Unsure	4	7.7					
Reduction in the maximum number of pots per vessel that can be used on the east coast	Effective	25	49.0	Yes	15	30.0	5.233	0.073
	Not very	7	13.7	No	32	64.0		
	Not at all	19	37.3	Unsure	3	6.0		
	Unsure	0	0.0					
Priority access be given to operators with a proven history of fishing the east coast region	Effective	21	40.4	Yes	13	27.1	7.225	0.027
	Not very	7	13.5	No	30	62.5		
	Not at all	19	36.5	Unsure	5	10.4		
	Unsure	5	9.6					
Leave industry to work it out themselves, for example through a voluntary code of conduct	Effective	13	25.0	Yes	14	29.2	4.945	0.084
	Not very	15	28.8	No	23	47.9		
	Not at all	13	25.0	Unsure	11	22.9		
	Unsure	11	21.2					

Recreational catch rates and fisher behaviour

Recreational fishers tend to be responsive to changing catch rates, both in terms of general participation rates and individual levels of effort, especially in highly consumptive fisheries, such as that for rock lobster. To test this, the estimated proportion of licence-holders who actively fished for rock lobster (noting that not all licence-holders fish), the average days fished and average harvest per active licence-holder in a given season were regressed against the estimated average catch rate in that season. This analysis was based on recreational survey data conducted since 2000 and demonstrates a strong positive relationship between seasonal catch rates and the proportion of licence-holders who fish, the average number of days fished and average individual seasonal harvest (Fig. 25). These are important behavioural relationships given that, with stock rebuilding, east coast catch rates are expected to improve. Higher catch rates are thus likely to attract increased participation (licence numbers) and overall fishing effort, making it even more likely that recreational catches will continue to exceed the catch share allocation (and increase further) without additional management intervention.

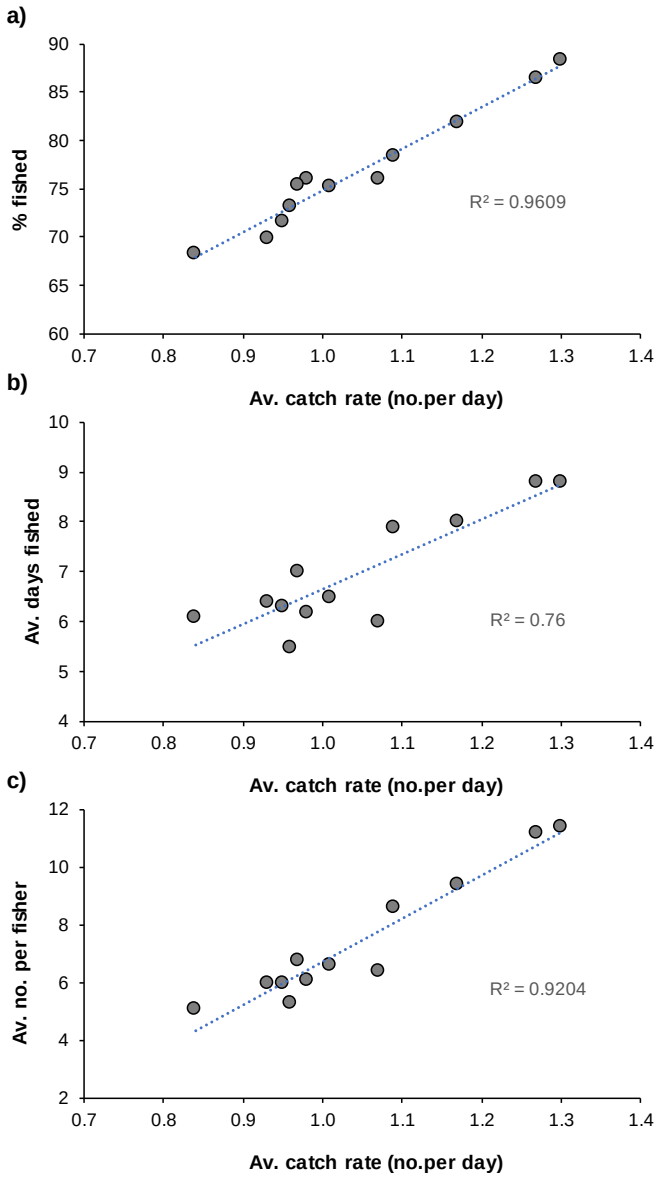


Fig. 25. Relationships between the average daily catch in a fishing season and a) proportion of active recreational licence-holders, b) average days fished for lobster by active licence-holders, and c) average seasonal catch of lobster by active licence-holders for that fishing season.

Recreational “fleet” projections

Recreational CPUE was projected for both dive and pot methods based on commercial CPUE projections as outlined in the methods section. As shown in Fig. 26, recreational potting CPUE is expected to continue to increase substantially over the next few years whilst dive CPUE will begin to plateau more quickly due to the impact of the bag limit. The percentage reduction in CPUE that the bag limit creates for each sector is shown in Fig. 27. Whilst the bag limit currently primarily effects the dive sector it will play an increasingly important role in constraining any increase in catch rates from recreational potting. This is particularly the case in Area 2 due to the expected high increase in CPUE as stocks rebuild.

Substantial increases in licence numbers are expected in response to increasing CPUE (Fig. 28). This projection is based on changes in total licence numbers that occurred during the period of substantial CPUE increase in the early 2000s and then responses to subsequent declines in CPUE. The model used here assumed that the number of licence-holders accessing the East Coast would follow the same trend. It is, however, very difficult to predict human behaviour and this analysis aims to provide an indication of possible trends in licencing rather than providing a high accuracy projection thereof. In particular, this may over-estimate increases in participation as there is likely to be a saturation limit, i.e. there is a limited number of people who will go fishing regardless how high CPUE is.

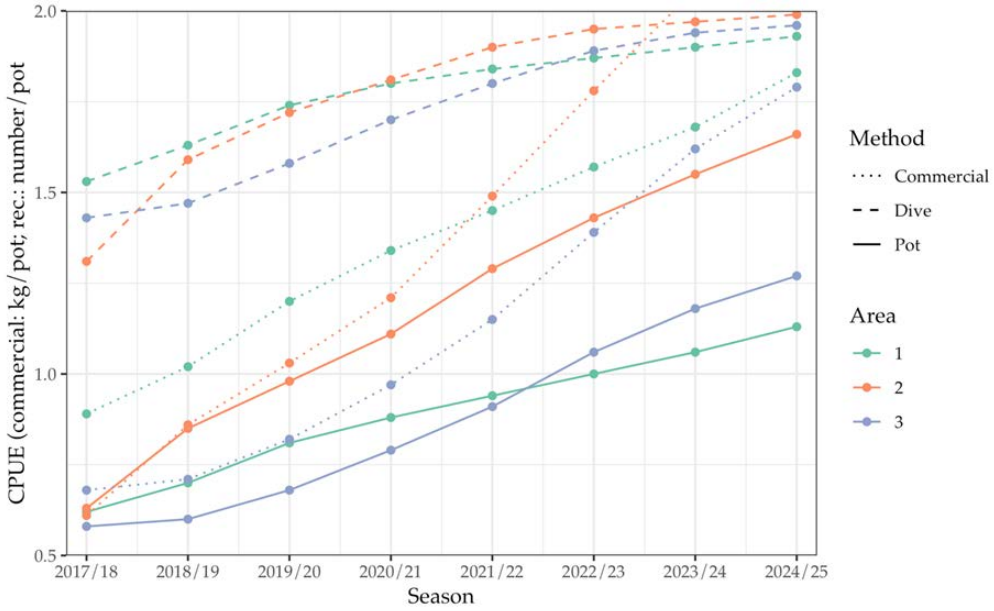


Fig. 26. Projected commercial and recreational CPUE. Note that recreational CPUE is shown in numbers/pot whilst commercial CPUE is shown in kg/pot.

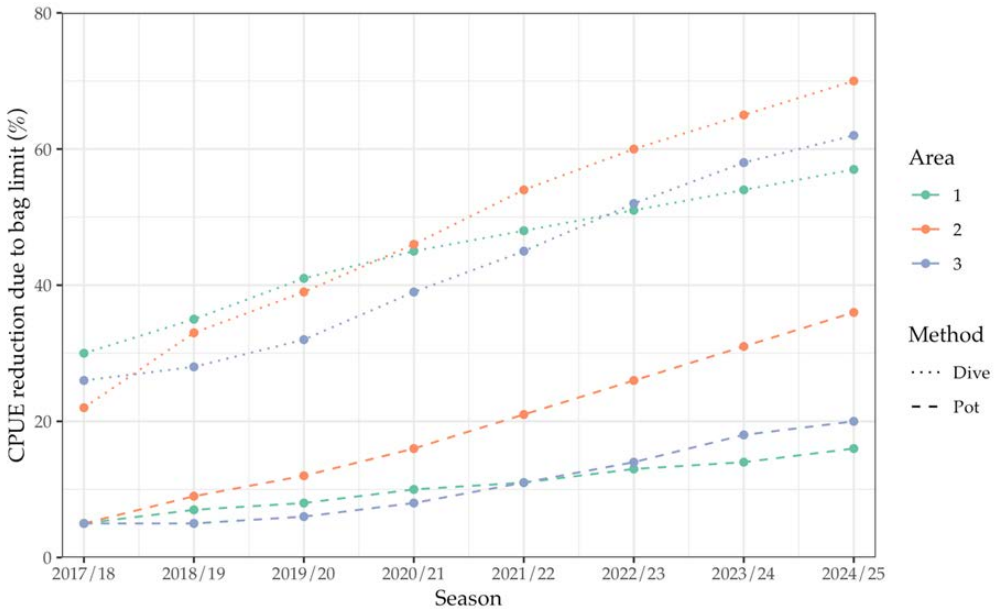


Fig. 27. Reduction in CPUE that the bag limit currently produces and is projected to produce in future years.

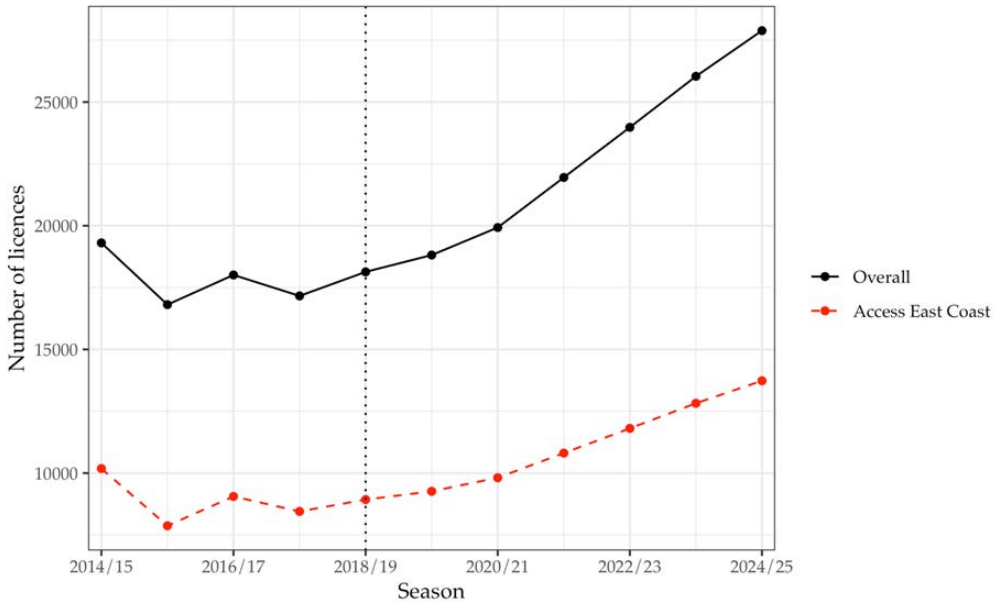


Fig. 28. Numbers of recreational rock lobster licence-holders (overall) and the number of licence-holders that access the East Coast (areas 1-3). Values prior to 2018/19 are based on the recreational surveys, values from 2018/19 inclusive are model-based.

If current levels of effort are maintained, the predicted increases in CPUE alone are anticipated to lead to substantial increases recreational catches (Fig. 29). For stock assessment Areas 1-3, the catch is expected to rise from 53.6 t in 2018/19 to 79.0 t in 2022/23. In practice, this is likely to be an underestimate since improving catch rates are also expected to attract higher recreational participation (refer also Fig.25). By incorporating this effect (as shown in Fig. 28), the increase in recreational catch is higher, reaching 104.4 t in 2022/23 (Fig.29). However, as previously noted there is likely to be saturation limit on participation and hence the two catch trajectories provide likely upper and lower bounds on recreational catch increases in the absence of additional management measures.

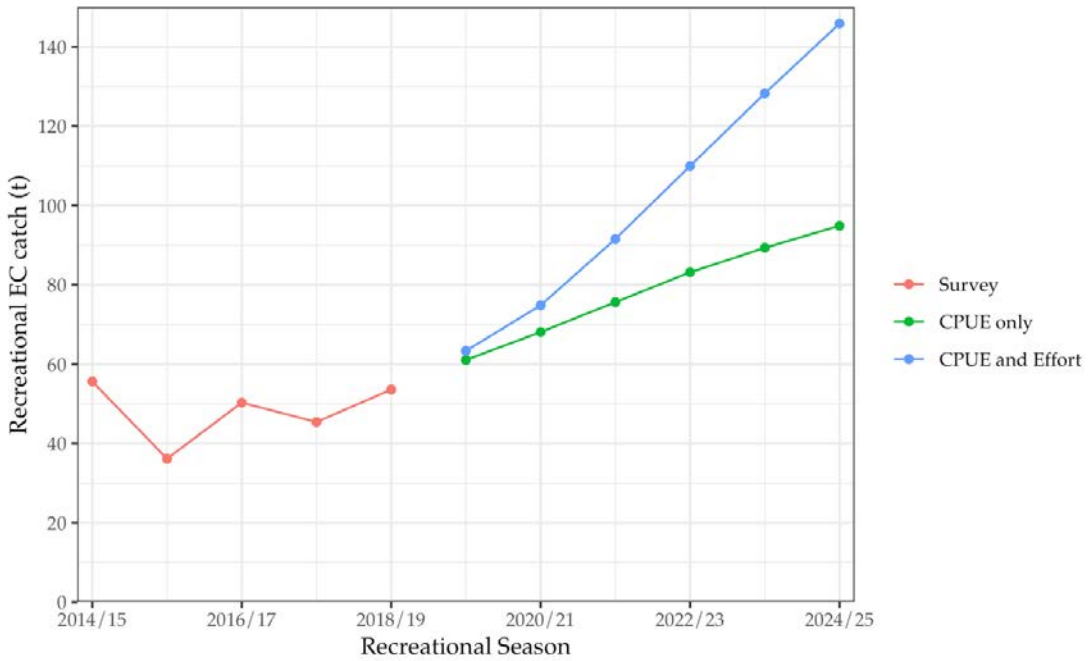


Fig. 29. Recreational East Coast catches. Values prior to 2019/20 are based on recreational survey data, values from 2019/20 onwards are based on the described models. The green "CPUE only" line considers the impact of increasing CPUE on the catch whilst assuming recreational fishing effort to remain constant. The blue "CPUE and Effort" line also considers the likely increase in effort due to greater recreational participation on the East Coast. Note that this catch projection was developed for the stock assessment model which has different boundaries to the ECSRZ, and this projected catch is for the entirety of stock assessment Areas 1, 2 and 3.

Due to the expected increased CPUE and higher participation, the effective share per fisher of the ECSRZ recreational catch allocation will reduce through time as shown in Fig. 30. By 2023/24 this will have decreased to 3.2 kg/fisher or 1.7 days of fishing. From a recreational "fleet" perspective, total effort in 2023/24 will need to be reduced to 54% of the 2018/19 level to maintain catches within the ECSRZ allocation (Fig. 31).

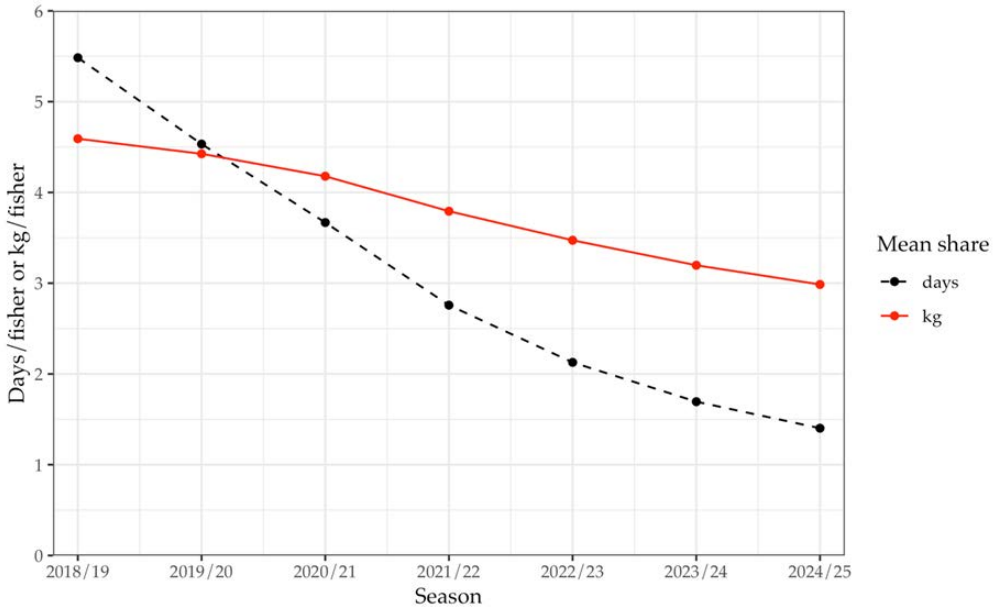


Fig. 30. The projected number of days fishing and the annual catch per licenced fisher that are available within the ECSRZ recreational allocation.

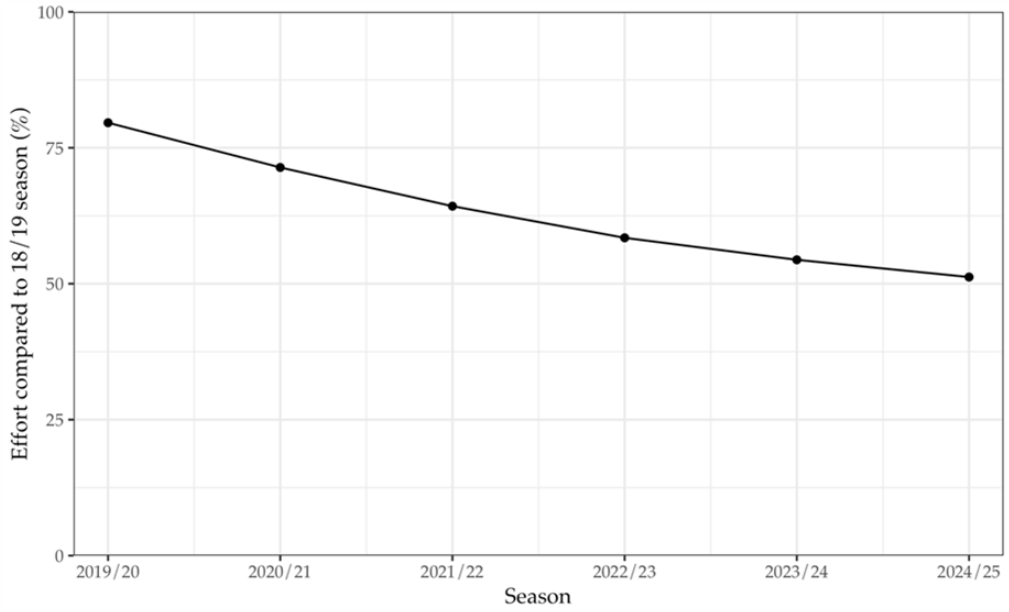


Fig. 31. Recreational fishing effort, relative to 2018/19, required to take the ECSRZ catch share allocation. As there was an over-catch in 2018/19, less than 100% of this effort should have been permitted to maintain the catch within the limit.

East coast commercial fleet characteristics

Since 2010/11 the number of commercial vessels operating in the rock lobster fishery has been steadily declining (Fig. 32), attributable to rising CPUE making it easier to catch the TACC and economic forces driving consolidation of catching by the most efficient operators. From 2010/11 to 2017/18 the state-wide fleet declined by 59 vessels whilst the number of vessels reporting catches in Areas 1-3 declined by 48. The rate of fleet reduction in the East Coast region has been proportionally higher than for the rest of the state, and since 2015/16 has exceeded the reduction in the rest of the state in absolute terms.

The decline in the number of vessels fishing off the East Coast since 2010/11 has been largely driven by the combined effect of increasing CPUE and decreasing catch, reducing the effort required to take the catch, which in recent years has been constrained by the ECSRZ catch cap. As shown in Fig. 33 the number of shots decreased by 57% between 2010/11 and 2017/18. A smaller contributing factor has also been an increase in the average number of pots used by vessels (which reduces the number of shots required for a given catch). East Coast shots have typically involved fewer pots per shot than the State-wide average (Fig. 34), suggesting potential for the required fishing effort (in terms of shots) to be reduced further as a result of changing fishing behaviour and/or vessels operating in the East Coast areas.

To understand the impact of the East Coast cap and the effect of the likely ongoing decline in season length it is necessary to understand the nature of those vessels fishing the East Coast and in particular those vessels taking most of their catch in this region. The number of vessels taking most of their catch in East Coast areas has declined through time. In 2017/18, 20 vessels took >90% of their catch in areas 1, 2 and 3, and 37 vessels took >50% (Fig. 35). Vessels that took most of their catch in East Coast areas in 2017/18 were analysed and found to have consistently fished that region in previous years (Fig. 36). This consistency through periods of high CPUE variability including extremely low CPUE years and substantial catch reductions suggests that these vessels may have limited capacity to fish outside this region.

The number of shots required to take the east coast catch may reduce to 39% of the current level by 2022/23 (Fig. 37), this is due entirely to the projected CPUE increase. This reduction could be exacerbated to 34% if vessels utilised the current maximum entitlement of 50 pots. A substantial factor not considered here that could reduce the rate of this reduction is that there has been a shift to more winter fishing (with lower CPUE) because of the race-to-fish and in pursuit of higher beach prices.

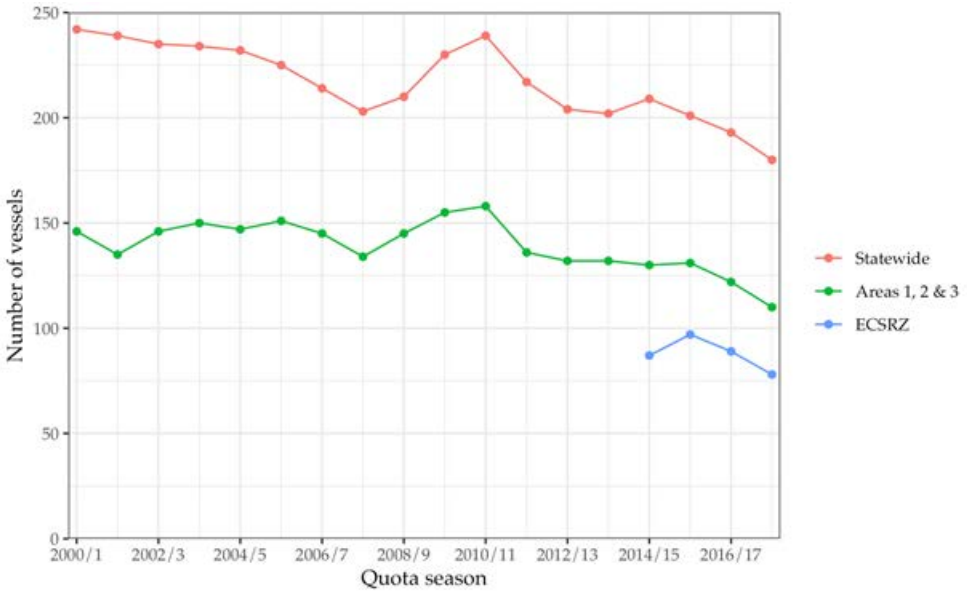


Fig. 32. Number of vessels reporting catch state-wide, in assessment areas 1, 2 and 3 and in the ECSRZ in each quota season.

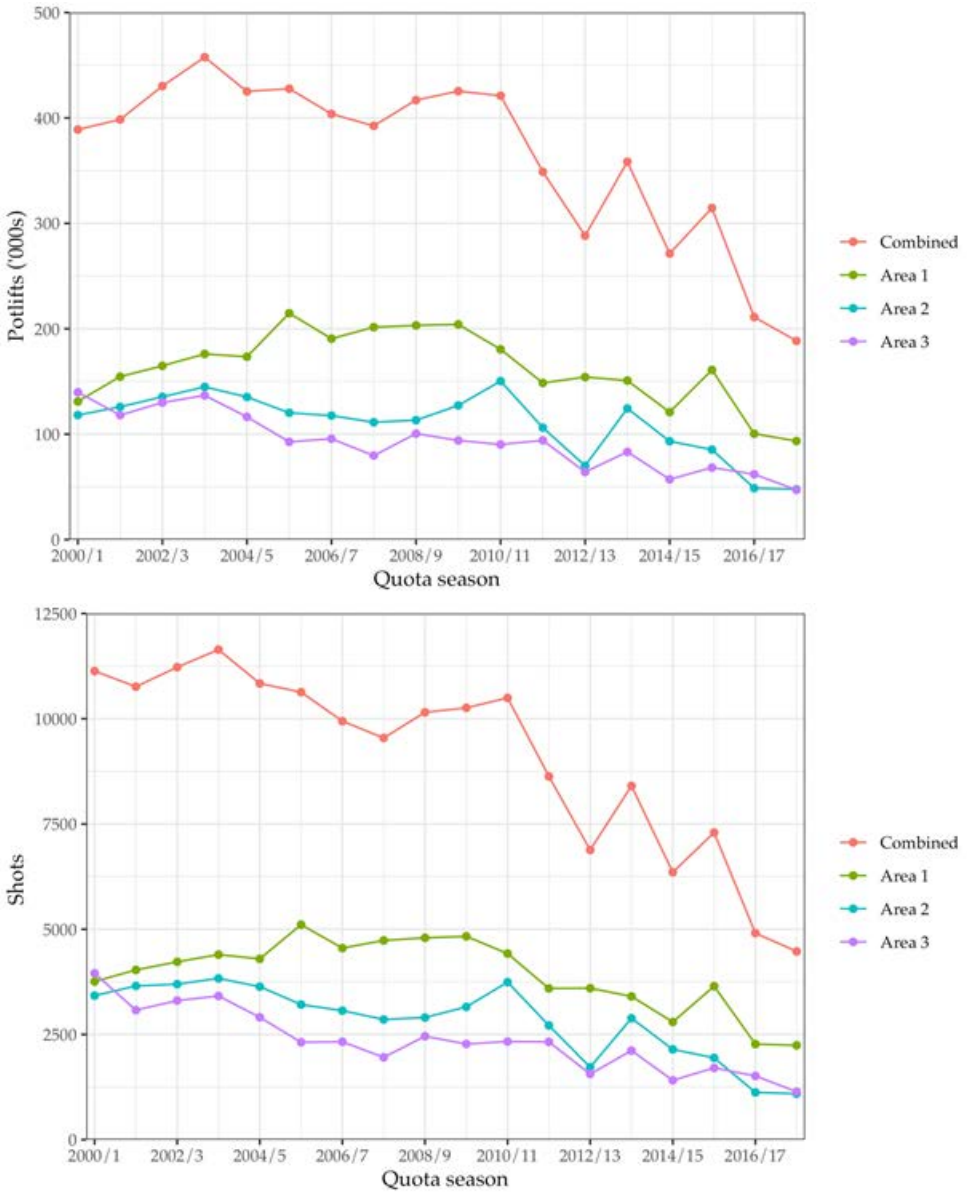


Fig. 33. Effort in areas 1, 2 and 3 individually and combined. The top panel shows the number of potlifts conducted. The bottom panel shows the number of shots (gear sets).

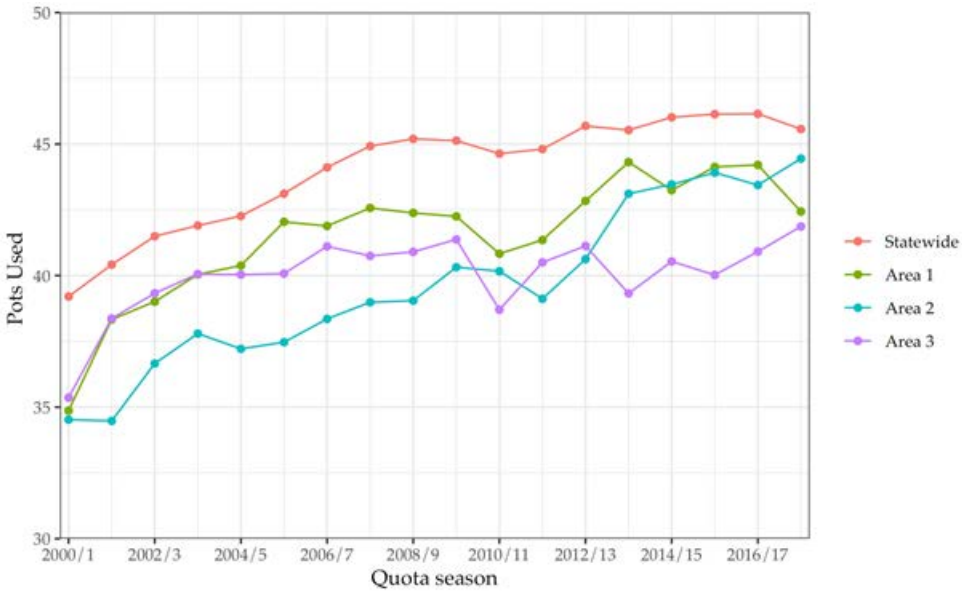


Fig. 34. Mean number of pots per shot State-wide and for East Coast assessment areas (1-3).

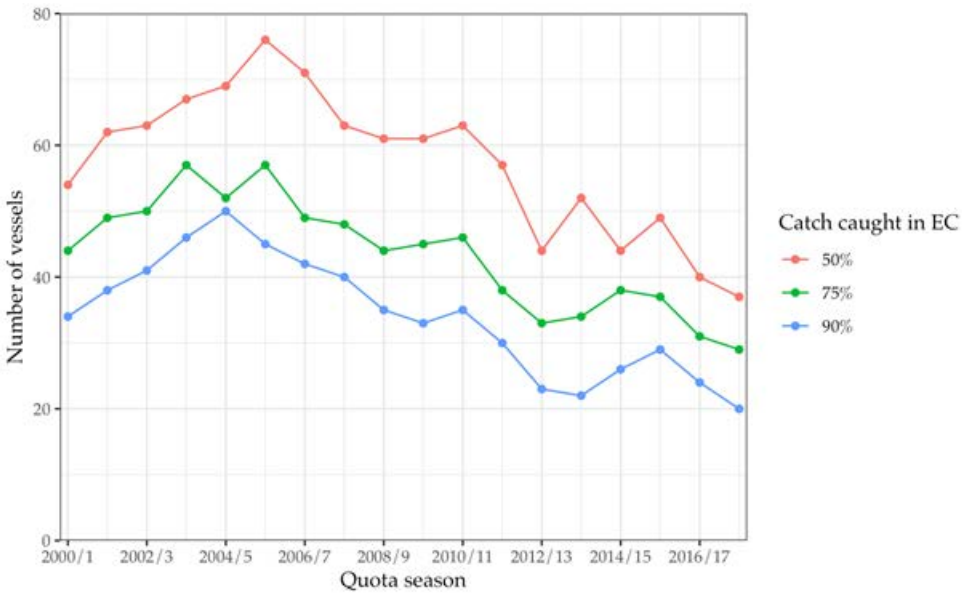


Fig. 35. Number of vessels catching at least 50%, 75% or 90% of their total catch in East Coast assessment areas 1, 2 and 3 in each season.

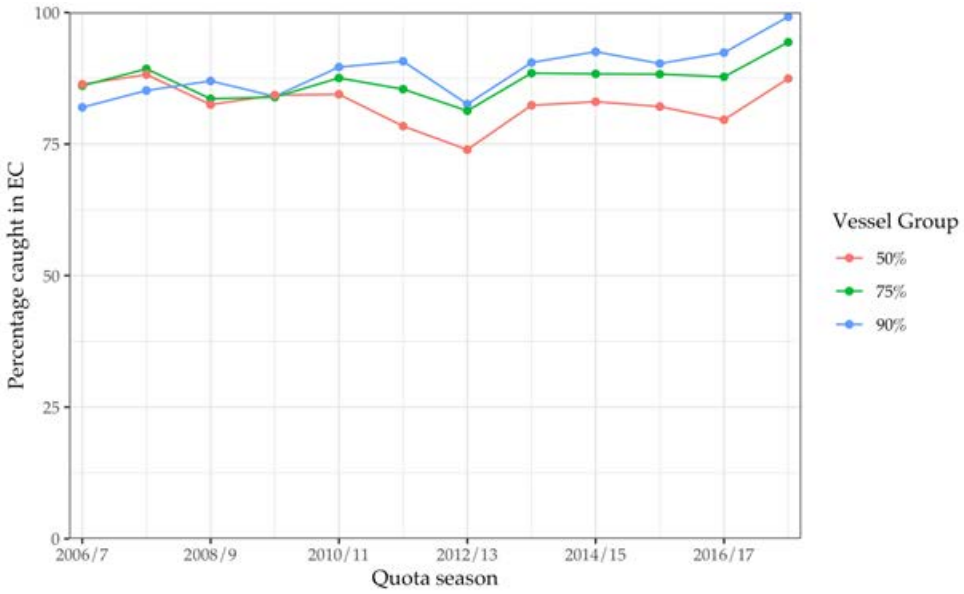


Fig. 36. The mean proportion of a vessel's catch taken in the East Coast for groups identified as East Coast fishers in 2017/18 on the basis of having caught at least 50%, 75% or 90% of their catch in the East Coast in that year.

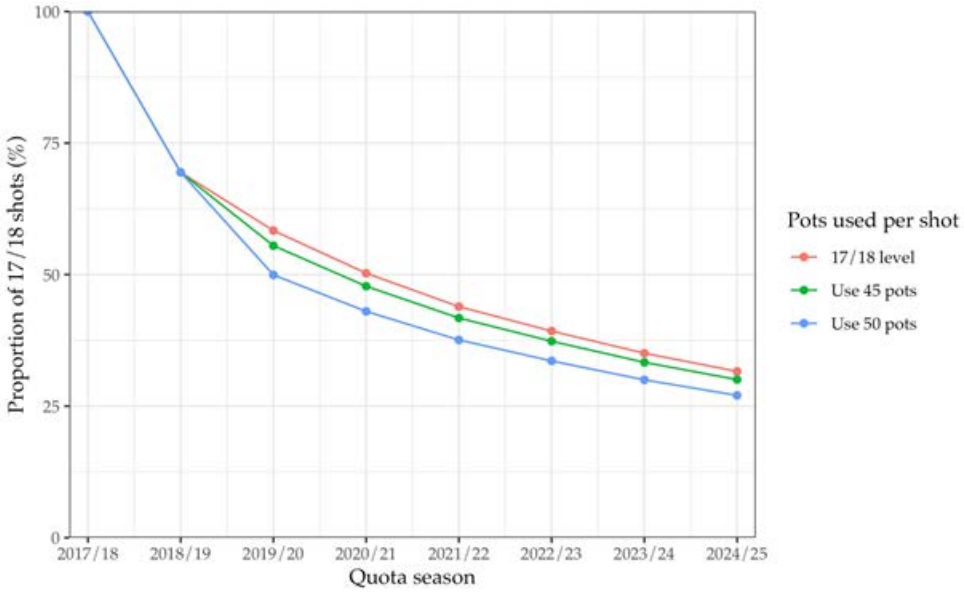


Fig. 37. Number of shots required to take the commercial East Coast catch as compared to the number of shots conducted in 2017/18. Scenarios for different numbers of pots per shot are shown, firstly the 2017/18 level, secondly an increase to 45 pots per shot and lastly an increase to 50 pots per shot.

Assessment model projections

The impact of the previously considered recreational catch increases was considered by including these catches in the Tasmanian rock lobster stock assessment model. Two scenarios were examined. The first scenario considered the implications of unrestrained increasing recreational catches on east coast stock rebuilding (as per Fig. 29). The second scenario considered the impact on the remainder of the Tasmanian rock lobster stock if the overall ECSRZ catch was maintained at target levels by offsetting recreational over-catch with equivalent reductions in the ECSRZ commercial catch cap. In the absence of any TACC adjustment this would have the effect of increasing the commercial catch in the remainder

of the state. The first of these model scenarios corresponds to the base case management scenario, and the second to alternative management scenario B.

These scenarios effectively bracket the range of possible outcomes for the east coast and the remainder of the state as a result of increasing recreational catches. Any management measures that act to reduce recreational catches would have a proportional reduction on the impacts shown here.

Scenario 1

The projected increased recreational catches will substantially reduce the rate of rebuilding in the ECSRZ (Fig. 38). Under the rebuilding strategy, Area 2 is currently predicted to just meet the rebuild target of 20% unfished biomass by 2023, consequently any additional catch in this area will result in failure to meet this target. With a low level of over-run (based on CPUE increase only) the biomass in 2023 is expected to be 17.6%, with a high level of over-run (CPUE and Effort) it is expected to reach 16.4% of the unfished level. In Area 3 the rebuild target is met if a low level of over-run occurs, however the high level of over-run prevents the target reference point from being attained by 2023. Area 1 is currently above the rebuild target, and although the extent of further rebuilding is affected by the level of recreational over-catch, stocks are still expected to remain above the target level. These outcomes are summarised in Table 17 and highlight that the target reference points (> 20% unfished biomass in all assessment areas) will not be achieved without management intervention to ensure the total east coast catches are maintained at the agreed level or at least effectively constrained.

Table 17. Year in which the 20% biomass target reference point will be met (or for Area 1 when it was met) for the three recreational over-catch scenarios.

Area-scenario combinations where the target reference deadline of 2023 is not met are highlighted.

		No over-run	Low over-run	High over-run
Area 1		2015	2015	2015
Area 2		2023	2026	Not met
Area 3		2022	2023	2025

Scenario 2

In this scenario, the commercial catch cap is reduced to offset predicted recreational over-catch and thus maintain the ECSRZ catch at the target level. The commercial catch offset is however shifted to other areas of the state. For Area 4, this will have no impact (Fig. 39) as this area is currently controlled by its own commercial catch cap (implemented in 2017/18) and intended to assist stock rebuilding in that area as well as aiding commercial fishers based in the area to make operational decisions based on the amount of quota left to catch in their main area of operation (https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/rock-lobster-fishery/north-east-catch-cap (accessed 11 July 2019)). Although Areas 6 and 8 are negatively impacted by the increased catch, biomass and egg production will continue to increase and remain at levels well above the state-wide target reference point of 25% unfished biomass and egg production (Fig. 39). In Area 5, the additional catch prevents the rebuild target of 20% biomass being achieved by 2023; the target is achieved by 2024 in the low over-run scenario and not until 2025 for the high over-run scenario. Area 7 is currently at 20.7% biomass and slowly increasing with a rebuild to 25% expected by 2023. There is no rebuild target for this area, however, a rebuild to the state-wide 25% target is desirable. The additional catch will slow and then halt this gradual rebuild before 25% biomass is reached.

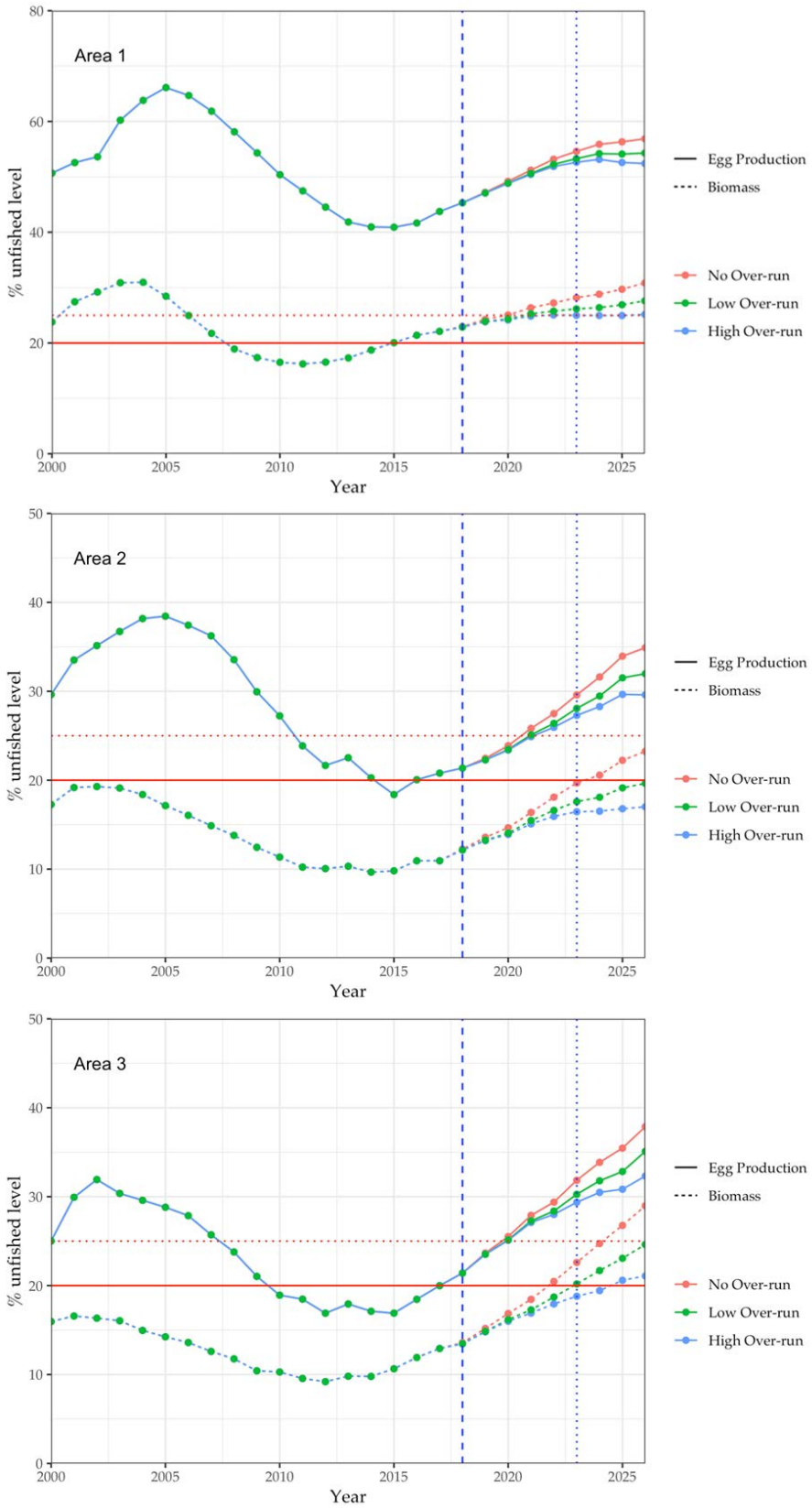


Fig. 38. Egg production and biomass (>60 mm) compared to the estimated unfished population. Three projection scenarios are considered i) recreational catch will continue to be maintained at the allocated level ("No over-run") ii) recreational catch will increase in response to CPUE ("Low over-run") and iii) recreational catch will also increase due to additional participation ("High over-run"). The ECSRZ aims to achieve 20% biomass (solid red line) in each area by 2023. The state-wide target reference point for 25% biomass by 2023 is also shown.

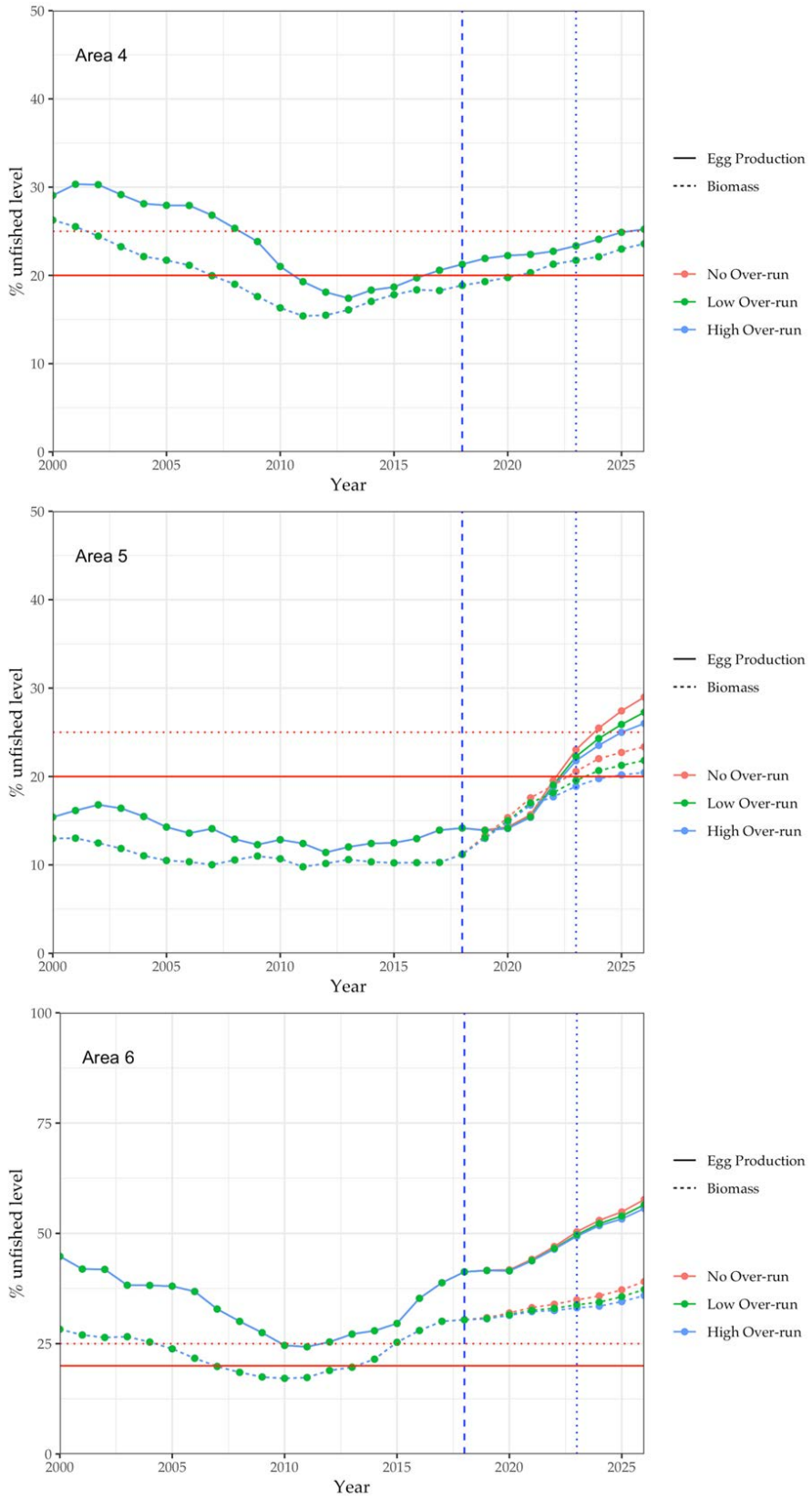


Fig. 39. Egg production and biomass (>60mm) compared to the estimated unfished population. The recreational catch scenarios considered in Fig. 38 are shown, however in this scenario it is assumed that in response to increasing recreational catches, the commercial ECSRZ allocation is reduced and hence the catch increases are effectively shifted outside of the East Coast. Current management aims to achieve 20% biomass (solid line) in all areas by 2023, outside of the ECSRZ there is a focus on Area 5. The state-wide biomass rebuild target of 25% is also shown. .

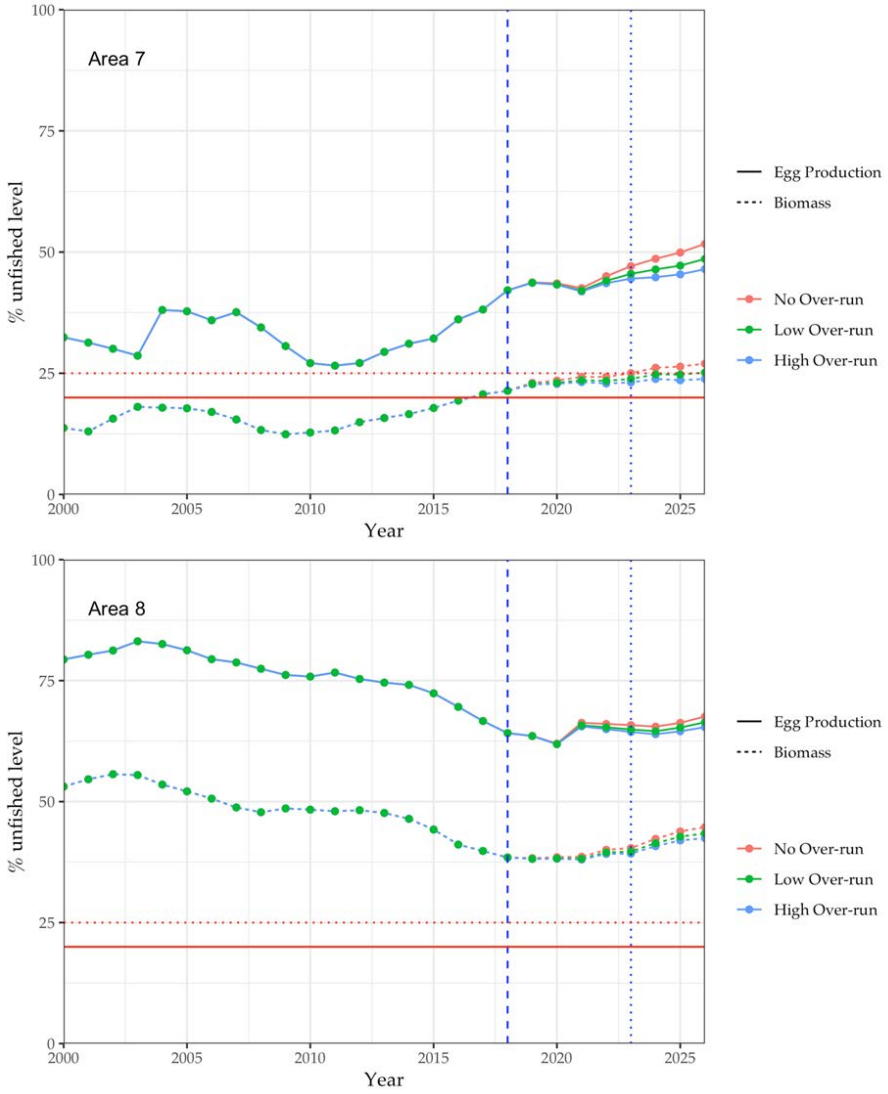


Fig. 39. Continued.

Policy analysis and scenario development

Evaluating options using cost-benefit analysis

Cost–benefit analysis (CBA) is used by fisheries management agencies to evaluate the desirability of a given intervention, or a range of alternative interventions, to address a challenge facing a fishery. It is an analysis of the cost effectiveness of alternative management options (including doing nothing) to see whether the benefits of any particular option outweigh the costs, above other options. CBA is recommended as a framework to guide fisheries decision making, including decision involving resource allocation or re-allocation (Building Economics into Fisheries Management Decision Making: FRDC project: 2016-13; Freese *et al*. 1995; Mangin *et al*. 2018).

Conducting a CBA involves two main steps: 1. determining the costs and benefits to include in the analysis; and 2. measuring those costs and benefits for each option and drawing conclusions from the comparison of costs and benefits. Determining what to include as costs and benefits is typically guided by the scope of government policy and management objectives for the fishery. Measuring costs and benefits is undertaken by applying economic valuation concepts and techniques to measure 'ecological' and 'social' costs and benefits (as economists view these as economic because they concern societal or global welfare), while what are often called 'economic' costs are measured using financial measures as they are often costs or benefits to private entities (e.g. loss of revenue to fishing firms). Social impact assessment techniques are also often used to identify less quantifiable social losses or gains (de Young *et al*. 2008).

The costs and benefits of the impacts of an intervention are evaluated in terms of the public's – or government's - willingness to pay for them (benefits) or willingness to pay to avoid them (costs). Total expected benefits and total expected costs are then compared to guide the decision as to the best option.

In this study a formal CBA of alternative management options or scenarios has not been conducted, in part because specific policy objectives for the Tasmanian Rock Lobster Fishery are not available as a basis with which to determine which benefits and costs to include. Instead, types of costs and benefits have been identified and recommended for inclusion should such an analysis be undertaken.

Determining types of costs and benefits

Management objectives for the purposes of this exercise have been inferred from various policy documents and recent management decisions (https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/rock-lobster-fishery/rock-lobster-fishery-overview; East Coast Stock Rebuilding Strategy; Gardner *et al*. 2012), as follows:

1. Ensure ecological sustainability of the fish stock and effected ecosystem
2. Consistent with ensuring ecological sustainability, ensure social, cultural, economic benefits are generated, in the interests of the Tasmanian community including resource users. These include:
    a. provide for recreational fishing opportunity and amenity
    b. provide for economic returns to be generated from commercial fishing by pursuing economic efficiency as well as some level of social returns in the form of minimum size and regional distribution of fleet
    c. provide for customary fishing opportunity and benefits to Tasmanian Aboriginal communities

Based on these inferred objectives, the following economic and social costs and benefits have been identified for the range of alternative management options investigated in this study (Table 18). Ecological costs and benefits are considered by identifying the effectiveness of the option in achieving the ECSRS target, which is assumed to generate net ecological benefits when met.

Table 18. Expected short term economic and social costs and benefits from base case and alternative management options.

Option	Costs	Benefits	Feasibility		
			Effectiveness at supporting ECSRS rebuilding target	**Compliance and fisher behaviour effects**	**Acceptance and practicality**
	No management intervention				
Base case scenario	No short term costs In the long term, lost opportunity cost from not gaining benefits from earlier rebuild	In the short term, current levels of recreational fishing utility increased as participation increases, and benefits from commercial fishing maintained	Not effective in assessment area 2. Rebuilding rate effectively slowed to below levels which achieve ecological sustainability goal	No anticipated additional compliance issues or compensatory behaviour from recreational fishers as status quo maintained	No practicality issues as no implementation. Likely to meet from strong opposition from environmental, fisher and other stakeholder groups for not achieving the ECSRS or ecological sustainability target in acceptable time frame.
	Operational management changes – Recreational fishing				
Limit number of Recreational Lobster Licences issued which permit access to the ECSRZ	Reduction in net opportunity to recreationally fish for lobster (greatest cost to non-avid and non-local fishers).	Improve quality of recreational fishing opportunity (less crowding) and availability of lobster for those who obtain a licence.	Indirectly constrain catch and effort; effectiveness will be influenced by the number of licences available and fisher behaviour (effort).	Potential for increased non-compliance. May not account for connectivity with areas outside ECSRZ.	Technically possible, moderate implementation costs, requirement for an allocation mechanism (e.g. ballot). Likely to meet strong opposition from recreational fishers.
Reduce daily bag limit (to one lobster)	Reduction in daily consumptive benefits for recreational fishers.	Longer term, improvement in lobster availability and therefore increase in recreational utility (assuming effective at constraining recreational catch).	Indirectly constrain catch; effectiveness will depend on fisher behaviour (effort). Potential increase in handling mortality.	Enforceable, but greater incentives for non-compliance and compensatory behaviour (increased effort and high grading).	Practical to implement, low implementation cost. Likely to meet strong opposition from recreational fishers.

Table 18. Continued

Option	Costs	Benefits	Feasibility		
			Effectiveness at supporting ECSRS rebuilding target	**Compliance and fisher behaviour effects**	**Acceptance and practicality**
Introduce Individual seasonal catch limit	Reduction in net opportunity to recreationally fish for lobster. Reduction in total consumptive benefits to recreational fishers (greatest cost to divers and high avid fishers).	Longer term, improvement in lobster availability and therefore increase in recreational utility (assuming effective at constraining recreational catch).	Ability to effectively constrain catch is dependent on individual seasonal allocation (maximum number of lobsters per fisher) and number of licence-holders.	Harvest tags represent a feasible monitoring system. Enforceable, but potential for non-compliance through tag reuse.	Technically possible, high implementation cost. Acceptance by recreational fishers will be determined by the individual seasonal allocation limit.
Manage to ensure maximum ECSRZ catch limit	Reduction in net opportunity to recreationally fish for lobster. Reduction in individual consumptive benefits to recreational fishers.	Longer term, improvement in lobster availability and therefore increase in recreational utility.	Potential to constrain catch to target level.	Implementation via: (i) release of predetermined number of harvest tags (requires an allocation mechanism); or (ii) through in-season monitoring of catches. Potential for non-compliance (tag mis-use) and deliberate mis-reporting and behavioural change (race-to-fish).	Technically possible, high cost of implementation. Harvest tags: comments as above, with the additional requirement for an allocation mechanism (e.g. ballot). In season monitoring: either survey-based or through mandatory reporting. Harvest tag option likely to meet strong opposition due to allocation process. In season monitoring likely to result in race-to-fish, creating uncertainly as to season duration and possible risk-taking behaviour.

Table 18. Continued

Option	Costs	Benefits	Feasibility		
			Effectiveness at supporting ECSRS rebuilding target	**Compliance and fisher behaviour effects**	**Acceptance and practicality**
Increase minimum size limit for females	Minor reduction in utility, with pot fishers more impacted than divers.	Longer term, improvement in RL availability and therefore increase in recreational utility (assuming effective at constraining total recreational catch)	Indirectly reduce catch in short-term (greater proportion of undersized lobsters in catch) but with potential to result in higher handling mortality.	Enforceable, but incentive for non-compliance and compensatory behaviour (increased effort)	Practical to implement and cost effective, general acceptance is likely from fishers based on changes apply to all sectors. Increased protection for unrecruited adult stock
Reduce season length	Reduction in net opportunity to recreationally fish for lobsters. Reduction in consumptive benefits for periods when season closed.	Longer term, improvement in lobster availability and therefore increase in recreational utility.	Directly constrain catch and effort; as catch rates improve season length will need to be increasingly restrictive.	Enforceable. Potential for compensatory behaviour (increased effort).	Practical to implement and cost effective. Acceptance by recreational fishers will be determined by how restrictive the season is, particularly in relation to impact on the peak fishing periods - Dec/Jan and Easter.
Complete closure for fishing year	Short term loss of recreational opportunity and consumptive benefits from recreational fishing for that period. Short-term reduction in contributions to regional economic activity from recreational fishing activity.	Increase rate of stock rebuild therefore improvement in stock sustainability (increase in option/behest value). Fewer other management constraints required therefore increase in recreational utility when fishery opened.	Constrain catch and recreational fishing opportunity only for the closure period. Benefits for the rate of stock rebuilding.	Enforceable. Potential for increased non-compliance behaviour.	Practical to implement and cost effective. Likely to meet considerable opposition from recreational fishers. Will have significant economic impact for commercial sector and regional centres.

Table 18. Continued

Option	Costs	Benefits	Feasibility		
			Effectiveness at supporting ECSRS rebuilding target	**Compliance and fisher behaviour effects**	**Acceptance and practicality**
Fisheries allocation policy					
Adjust catch sharing arrangements with the commercial sector to account for recreational over-catch	Reduction in economic returns to commercial fishers. Reduction in direct employment associated with commercial fishing for lobster on the east coast. Reduction in contributions to regional economic activity from commercial lobster fishing activity. Displacement of commercial effort and reduction in technical efficiency of commercial fleet (assuming no change made to the state-wide TACC).	Increase in recreational fishing utility (assuming recreational fishing participation increases as projected).	Recreational fishing effort and catch will need to be monitored for impact on reaching rebuilding target. Recreational fishing effort and catch may need to be further constrained, depending on changes in participation.	No anticipated additional compliance issues or compensatory behaviour from recreational fishers.	Practical to implement as catch sharing policy is already in place, moderate cost of implementation due to need for robust catch monitoring. Need for high confidence in recreational catch estimates due to implications for the commercial sector catch share allocation. General support likely from recreational fishers, strong opposition is likely from commercial fishers. Measure is inconsistent with the current east coast catch sharing policy.
East Coast Stock Rebuilding Strategy					
Reduce rebuilding rate to accommodate current and projected recreational over-catch	No short term costs. In the long term, lost opportunity cost from not gaining benefits from earlier rebuild.	In the short term, current levels of recreational fishing utility increased as participation increases, and benefits from commercial fishing maintained.	Rebuilding rate may need to be slowed below levels which achieve ecological sustainability goal.	No anticipated additional compliance issues or compensatory behaviour from recreational fishers (effectively status quo).	Likely to meet strong opposition from environmental, fisher and other stakeholder groups for setting rebuild rate to one that is not effective at achieving the ecological sustainability target in acceptable time frame. From ecological and fishery perspectives a sub-optimal and high-risk strategy.

Discussion

General

The Tasmanian rock lobster fishery is a key part of the state's social and cultural identity. Based on recreational licence numbers alone, it is evident that in any given year approximately 20% of Tasmania's more than 80,000 marine recreational fishers (refer Lyle *et al*. 2014; Lyle unpubl. data) have a direct interest in fishing for rock lobster. The value afforded to being able to consume fresh lobster with friends and family is also confirmed in the current study; noting that very little of the commercially caught rock lobster is retailed within Tasmania and thus for many Tasmanians access to Southern Rock Lobster is via the recreational fishery.

The management objective to rebuild east coast rock lobster stocks has necessitated the implementation of measures to constrain commercial and non-commercial catches off the east coast of Tasmania. For the commercial sector, the east coast catch has been significantly and effectively reduced by capping the quota that can be taken from the region. This has also involved some redistribution of effort into other regions of the state, thereby reducing the negative economic impact of this spatial management measure. It is acknowledged, however, that as stocks rebuild competition amongst commercial operators is expected to increase the race-to-fish. Although not a major concern for the commercial sector, those operators with greater dependency on the east coast may experience increasing economic hardship, with the catch cap being reached earlier in the fishing season.

Efforts to constrain the recreational catch to support stock rebuilding have included lowering of bag and possession limits and the progressive reduction in the length of the east coast fishing season. Current management settings have not, however, been effective in limiting the recreational harvest to the sector's allocated catch share. Recreational participation and effort are strongly linked to fishing success, such that as catch rates improve (with stock rebuilding) recreational effort and harvest are predicted to grow, indicating a need for additional management intervention if stock rebuilding catch targets are to be met. If unable to fish for rock lobster due to seasonal or spatial closures, recreational fishers are capable of substituting rock lobster for other fishing opportunities but are far less flexible than the commercial sector in being willing or able to redirect effort into other areas of the state that are open to rock lobster.

The primary challenge in achieving the east coast stock rebuilding objectives is, therefore, the management of the recreational component of the fishery and the implications for the stock recovery and more generally the health of Tasmania's rocky reef ecosystems.

Recreational fisheries management

Recreational fisheries are typically managed under open access or some form of regulated access, including licensing, restricted seasons, size and individual bag or possession limits (Abbott 2015, Abbott and Willard 2017). Traditional management instruments have, however, proven to be largely ineffective in constraining catches (Cox *et al*. 2002; Lewin *et al.* 2006; MacKenzie and Cox 2013), being unable to limit overall participation or account for the adaptive behaviour of fishers (Fenichel *et al*. 2013). Thus, in situations where catches need to be restricted, for instance to support stock rebuilding or allocated catch shares, increasing regulation and shorter seasons are often necessary (Mitchell and Baba 2006; Doerpinghaus *et al*. 2014; NOAA Fisheries 2019). This has been the situation in Tasmania, with the recreational fishery divided into Eastern and Western Regions in 2011 to enable management responses to be targeted in the region of need. Key initiatives in the Eastern Region have included the progressive reduction in daily bag limit, from 5 to 3 in 2011 and from 3 to 2 lobster in 2015, and shortening of the fishing season. A winter closure was first introduced in 2015/16 (reducing the season from about 38 to 27 weeks) and there have been progressive delays in the opening date for

the season (traditionally the first weekend in November but by 2018/19 the opening was delayed by five weeks). While these measures have had some impact on recreational catch and effort, they have not been sufficient to constrain catches to the target level.

A case study that is particularly relevant to the challenges being experienced in management of the east coast rock lobster fishery is the US Gulf of Mexico red snapper fishery. The red snapper fishery is a mixed recreational and commercial fishery that has been historically overfished and is subject to a stock rebuilding strategy based on reducing fishing mortality from all sectors (Doerpinghaus *et al*. 2014; NOAA Fisheries 2019). As for the ECSRS, a total catch target has been specified, with explicit proportional allocations to commercial and recreational sectors. The commercial sector is subject to quota management (ITQs) and thus removals are controlled directly. The recreational fishery, on the other hand, is a subject to licensing (unlimited entry), minimum size limits, bag limits and seasonal closures. Despite significant stock rebuilding and increases in the TAC, management of the recreational sector has become increasingly restrictive. Progressive and significant reductions in recreational bag limits (reduced to two fish per day since 2007) and season duration (reduced to just 10 days in 2015) have been implemented in an attempt to constrain recreational catches to within the sectoral allocation. In addition, near real time monitoring of recreational catches is now undertaken by the Gulf states, using a combination of mandatory reporting (for example *Tails n' Scales* program and app in Mississippi) or targeted surveys (combination phone / mail surveys to estimate effort and creel surveys to estimate catch rates). These data are used to track and predict within season catches, with the fishing season closed if the recreational catch allocation is assessed to have been reached. In effect the recreational fishery has become a race-to-fish and, notwithstanding the approach to catch monitoring and management, recreational catches have exceeded the sector's allocation in most years. Improved catch rates have combined with higher participation and effort to pose major challenges for management, a situation comparable to that facing the Tasmanian rock lobster fishery. US authorities now recognise that new and innovative solutions are required, there are no simple solutions to managing recreational catches within restrictive catch limits, especially using conventional management approaches.

Fisher management preferences

The recreational fisher surveys indicated strong opposition towards any further reduction in daily bag limit, with low perceived effectiveness and support for the measure as well as confirming that any reduction would significantly impact fishers' utility. Such a response was anticipated as rock lobster is a highly consumptive harvest-oriented fishery. A reduction in season length was another management setting that was found to significantly impact most fishers' utility, the trade-off between season length and daily bag limit having little variability across fisher groups. In contrast, we found heterogeneous preferences for an introduced maximum seasonal catch and an increase in minimum size limit for females. These results may reflect the fact that these measures limit catch indirectly whereas a reduction in bag limit and shortened season have direct and clear implications on expected catch and recreation time.

Among fishers who use different fishing methods, the phone survey suggested that divers were the most supportive group for further management, although the DCE suggested that this group would be the most impacted if a maximum seasonal catch limit was implemented. This was indicated by the largest trade-off required in the maximum seasonal catch and is expected because daily catch rates for divers tend to be significantly higher (by a factor of two times) than for potters (Lyle and Tracey 2016a,b; Lyle 2018). However, our results also suggest that most fishers would be affected if a maximum seasonal catch limit was implemented to meet the stock rebuilding goal. Given the number of recreational fishers who typically fish for rock lobster within the east coast rebuilding zone (~ 10,000) (Lyle and Tracey 2016a, b; Lyle 2018) the average seasonal catch would need to be ~ 4 lobster per fisher to meet the 40-tonne total allowable recreational catch. This is considerably lower than what was perceived to be acceptable as an individual seasonal catch limit (median of 20 lobsters).

Recreational fishing specialization, which is defined as a spectrum from "general interest and low involvement to specialized interest and high involvement" (Bryan, 1977) is correlated with avidity (Han and Oh, 2018). For different levels of avidity, low avid fishers were generally most supportive for all management instruments in the phone survey, except limiting the number of licences. This coincides with the findings in Salz & Loomis (2005), in which low specialized fishers were more supportive for regulations and acknowledged the detrimental impacts recreational fishing has on fish stock more than high avid fishers do. In our DCE results, low avid fishers, however, also showed a relatively large trade-off in the introduced seasonal catch limit, even though such a limit is less likely to constrain their behaviour. This was the case in Salz *et al*. (2001) where support for regulations increased as specialisation increased in all regulations other than restricted fishing areas. Theory of specialisation in fisheries suggests that high avid fishers would be more accepting of further regulations (Bryan, 1977). Our results were contrary to this for size limit for females and an increase in penalties. Additionally, high avid fishers would be impacted by an increase in size limit for females. The estimated trade-off also suggests that the high avid fishers would dislike an increase in penalties for non-compliant acts.

Fisher response to stock rebuilding

Catch rates for commercial and recreational sectors are expected to increase substantially as a direct consequence of the rebuilding strategy. Over the next five years commercial CPUE in Areas 1, 2 and 3 is expected to increase by 65%, 140% and 228%, respectively, whilst recreational potting CPUE increases (which are constrained by the bag limit) are expected to be in the order of 51%, 82% and 97%, respectively. For the commercial sector this will lead to further reduction in season length within the ECSRZ, resulting in earlier and earlier closures. This fishery is likely to become a predominantly early season (autumn) and winter fishery. For the recreational sector and in the absence of additional management restrictions, the combined effects of higher CPUE and participation are predicted to lead to an increase in the east coast catch of between 57 and 125% above 2018/19 levels by 2023. Increases to this level will undermine the stock rebuilding strategy and prevent the stock rebuilding target of 20% virgin biomass being achieved in Area 2 and possibly Area 3.

Model projections suggest that to maintain catches within the recreational catch share allocation will require a reduction of effort to half of the 2018/19 level by 2023/24. To achieve this with existing input controls will be a formidable challenge, especially in the context of anticipated increased participation arising from increasing CPUE. The average individual share of the overall allocation will decrease to 3.2 kg or 1.7 days of fishing, consequently input controls such as reduced seasons may have limited effect as participants have substantial flexibility in compensating for these.

The alternative of maintaining the total East Coast catch at the target levels by off-setting recreational over-catch against the commercial catch share would lead to increased fishing pressure on other areas of the state. Without additional management changes this redistribution of catch is predicted to prevent achieving the rebuild target in Area 5 and cause rebuilding in Area 7 to plateau at less than 25% of unfished biomass. Consequently, if this approach was to be considered, management changes such as a TACC reduction (equal to the amount of catch re-allocated between sectors on the East Coast) or the introduction of further spatial management to support the rebuild in Areas 5 and 7 may need to be considered.

Management options

Using a multidisciplinary approach this study has highlighted the key challenges to developing an effective management framework to support the rebuilding of the east coast rock lobster stocks. Challenges that are compounded by the lack of clear policy direction for the Tasmanian Rock Lobster Fishery. In particular there is little clarity surrounding social, cultural and economic objectives which represent a significant hurdle to evaluating costs and benefits of alternative management options. Notwithstanding this and assuming the *status quo* (i.e. base case scenario) is not desirable it is evident

that further and substantial management intervention will need to be considered if the east coast stock rebuilding goals are to be met.

Within the context of potential management scenarios, those that pursue the current rebuilding objective are of greatest relevance, whether based on adjustments to settings of existing management instruments or consideration of additional management instruments (alternative management scenarios A and B, respectively, Table 3). It may also be reasonable to review the east coast catch share split as an element of future management direction. However, the absence of policy guidance around fisheries allocation (or reallocation) in Tasmania means that any such determination would ultimately need to be a political decision. Any re-allocation in favour of the recreational fishery that might ease the regulatory burden on the sector would still need to ensure that recreational catches are effectively monitored and constrained within the catch share arrangements.

Although it is beyond the scope of this study to make direct recommendations about the management of the east coast rock lobster fishery, the following observations are expected to assist in future decision making.

In relation to adjustments to existing management settings:

- Reduction in the daily bag limit to one lobster will assist in reducing catches but is expected to meet significant stakeholder resistance.

- Reducing season length has proven relatively effective in constraining recreational catches, highlighted in 2015/16 and 2017/18 when unexpected biotoxin closures during the peak fishing periods contributed to east coast catches being close to the target levels (refer Fig. 5). There is little doubt, however, that the timing and uncertainty surrounding these closures made trip planning difficult for recreational fishers and disproportionately contributed to reducing the effort in those seasons (Lyle and Tracey 2016b; Lyle 2018). Survey data from the 2018/19 recreational fishing season provides insight into the level of restriction that would theoretically be required to take the ECSRZ catch share (Lyle unpubl. data). The 40 tonnes catch share was estimated to have been caught within 12 weeks (of the 20-week season), but with the predicted increases in recreational CPUE (Fig. 26) the catch would be taken within 8 weeks in 2019/20, and in just 5 weeks by 2022/23 (Lyle unpubl. data). This analysis highlights the fact that the fishing activity is particularly intense at the start of the season but does not account for any potential changes in fisher behaviour due to the reduced season (such as maximising fishing opportunities within the limited window of opportunity). Thus, if season length is chosen as the primary instrument to constrain east coast catches it is likely that the season will need to be progressively and significantly reduced through time, minor adjustments will not be sufficient to achieve the catch share target. As a strategy, increasingly restriction is also likely to result in growing stakeholder dissatisfaction which could significantly alienate recreational fishers.

- Maintaining existing management settings will result in catches that substantially exceed the catch target. In turn this will prevent the rebuild goals being achieved until at least 2026 (in Area 2), or under a scenario with substantially increased recreational participation the rebuild goal may not be achievable. Consequently, *status quo* management is incompatible with the objectives of the ECSRS.

- Allocation of a greater portion of the east coast catch to the recreational sector will reduce the effort reductions that must be achieved by recreational input controls. The reduction in the commercial allocation would exacerbate the race to fish and have a substantial impact on vessels that routinely take the majority of their catch in the ECSRZ. A shift of catch to the rest of the state will undermine other regional rebuilding goals. Consequently a TACC reduction or introduction of other regional management measures may be required.

In relation to alternative management instruments:

- The concept of a maximum individual seasonal catch limit has some merit, not the least in that it ensures a more equitable distribution of the catch between fishers. However, because there is no limit on the number of recreational licences issued each year such a system cannot directly control the overall catch. Nonetheless, there is in principle support for seasonal catch limits from many stakeholders, although expectations about what these limits should be are significantly higher than what would be required to achieve the catch share allocation (Lyle and Tracey 2016a, this study). Catch or harvest tags represent a practical means to implement such a measure and have been used widely for game hunting in Australia and overseas but less so for fishing and, where applied, are generally available without strict rationing (Johnston *et al.* 2007). Catch tags for rock lobster were recently introduced into Victoria with recreational licence-holders issued batches of 20 tags at a time and a requirement that tags must be reported used before additional tags will be issued to the individual (https://vfa.vic.gov.au/recreational-fishing/tagging-of-recreationally-caught-rock-lobsters, accessed 24 July 2019). Typically, most tagging programs, including the Victorian rock lobster tagging program, are implemented to improve information on catch and effort but the accuracy of reporting is an important consideration, noting that reporting rates are often poor, even if reporting is mandatory (MacKenzie and Cox 2013). If there is a need to limit the harvest then a mechanism to allocate tags, such as some form of lottery or ballot, maybe required (Johnston *et al.* 2007; Jackson *et al.* 2016).

  The potential to introduce catch tags in the Tasmanian rock lobster fishery has already been the subject of a comprehensive government review (DPIPWE 2016a). This review concluded that there were significant risks to the implementation and on-going administration of a tagging system which could compromise its effectiveness. The review noted the potential misuse of tags, including through re-use and misreporting (especially if tag individual allocations are perceived to be lower than reasonable), the need for increased enforcement, the limited capacity to fund the costs of implementing and running the system, and uncertainty of achieving legislative support for what would be a fundamental change to the management of recreational fisheries in Tasmania. Adaptive behaviour by fishers in response to stock rebuilding is likely to complicate things and unless tags are applied in a restrictive manner, tags alone are unlikely to be sufficient to constrain the catches to within the harvest share.

- Mandatory catch reporting is extremely rare in recreational fisheries, but there are examples where this approach is applied to provide in-season catch monitoring with the objective of closing the fishing season as the cumulative harvest approaches a predetermined catch allocation. In effect this approach is comparable to the operation of the commercial catch cap. The Gulf of Mexico red snapper fishery provides an example of this approach whereby each of the Gulf States are required to manage their recreational catches to within explicit catch allocations. The method of catch monitoring varies between individual jurisdictions but of possible relevance to here are the mandatory reporting systems in Mississippi (Tails n' Scales program - http://dmr.ms.gov/index.php/component/content/category/159-snapper-tails-n-scales, accessed 17 July 2019) and Alabama (Snapper Check program - https://www.outdooralabama.com/mrd-fisheries-section/red-snapper-faqs, accessed 17 July 2019). Each fishing trip is required to be registered and the catch of species of interest reported; this can be done using smart phone apps, via the internet or phone. These data are used to monitor the catch within the season, noting that fishing is restricted to weekends only which provides time for authorities to collate catch data prior to the next pulse of fishing. These systems provide a framework for within-season catch monitoring and a potentially an effective means to actively manage the recreational catch. The practicality of such an approach in Tasmania is uncertain, the range of issues and considerations in evaluating the cost-benefits and feasibility are comparable to those around the use of tags to limit (rather than estimate) recreational catches.

Ultimately there are no easy or simple solutions to managing recreational fisheries, this study not only serves to emphasise some of the challenges confronting the Tasmania rock lobster fishery as it rebuilds but it is hoped will assist resource managers, recreational and commercial sectors in working proactively to meet these challenges.

Conclusion

The objective of rebuilding east coast rock lobster stocks has necessitated the implementation of measures to constrain both commercial and non-commercial catches. For the commercial sector the significant reduction in east coast catch has been achieved in part through a redistribution of effort into other regions of the state, thereby reducing the economic impact of this spatial management measure. Fishers acknowledge, however, that as stocks rebuild competition amongst commercial operators is expected to increase the race-to-fish. Although not a major concern for the sector, those operators with greater dependency on the east coast may experience increasing economic hardship, with the catch cap being reached earlier in the fishing season.

Recreational management settings have not, however, been effective in limiting the recreational harvest to the sector's allocated catch share. Recreational participation and effort are strongly linked to fishing success, such that as catch rates improve (with stock rebuilding) recreational effort and harvest are predicted to grow, indicating a need for additional management intervention if stock rebuilding catch targets are to be met. The primary challenge in achieving the east coast stock rebuilding objectives is, therefore, the management of the recreational component of the fishery.

Surveys of recreational fishers indicated strong opposition towards any further reduction in daily bag limit (currently two lobster), with low perceived effectiveness and support for the measure as well as confirmation that any reduction would significantly impact fishers' utility. Such a response was anticipated as rock lobster is a highly consumptive harvest-oriented fishery. A reduction in season length was another management setting that was found to significantly impact most fishers' utility. In contrast, we found heterogeneous preferences amongst fisher groups (fishing mode and avidity) for an introduced maximum seasonal catch and an increase in minimum size limits. These results may reflect the fact that these measures limit catch indirectly whereas a reduction in bag limit and shortened season have direct and clear implications on expected catch and recreation time. While there was majority in principle support for an individual maximum seasonal catch limit, the acceptable limit (median of 20 lobsters) was significantly greater than the average individual catch required to meet the east coast recreational catch share target.

As a direct consequence of the rebuilding strategy catch rates for commercial and recreational sectors are expected to increase substantially, although for the recreational sector the catch rate increase will become increasingly constrained by the bag limit. For the commercial sector this will result in earlier and earlier closures due to the catch cap being reached; the east coast fishery is likely to become a predominantly an early season (autumn) and winter fishery. For the recreational sector and in the absence of additional management restrictions, the combined effects of higher catch rates and participation are predicted to lead to an increase in the east coast catch of between 57 and 125% above 2018/19 levels by 2023. Increases to this level will undermine the stock rebuilding strategy and prevent the stock rebuilding target being achieved in at least one of the east coast stock assessment areas.

Model projections suggest that to maintain catches within the recreational catch share allocation will require a reduction of effort to half of the 2018/19 level by 2023. To achieve this with existing input controls will be a formidable challenge, especially in the context of anticipated increased participation arising from increasing catch rates.

The alternative of maintaining the total East Coast catch at the target levels by off-setting recreational over-catch against the commercial catch share would lead to increased fishing pressure in other areas of the state. Without additional management changes this redistribution of catch is predicted to prevent achieving rebuilding targets in some stock assessment areas outside of the east coast. Consequently, management changes such as a reduction in the total allowable commercial catch allocation or further spatial management to support rebuilding in impacted areas may need to be considered.

Implications

Using a multidisciplinary approach this study has highlighted the key challenges to developing an effective management framework to support the rebuilding of the east coast rock lobster stocks. Challenges that are compounded by the lack of clear policy direction for the Tasmanian Rock Lobster Fishery. Notwithstanding this and assuming the *status quo* is not desirable it is evident that further and substantial management intervention will need to be considered if the east coast stock rebuilding goals are to be met.

Although direct management recommendations are beyond the scope of this study there are several observations that are expected to assist in future decision making. In relation to existing management settings, season length is likely to be the most effective in constraining catches although progressive and significant reductions would be required to achieve the recreational catch share target. Minor adjustments, as implemented in the past have not been sufficient in this regard.

In relation to alternative management options, the concept of a maximum individual seasonal catch limit has merit, not the least in that it ensures a more equitable distribution of the catch between fishers. However, without limits on the number of recreational licences issued each year such a system cannot directly control the total catch. Catch or harvest tags represent a practical means to implement such a measure but there are risks and costs associated with implementation and administration of a such as system that require careful consideration.

In-season catch monitoring, whether based on reported tag usage, mandatory reporting or survey methods, could be applied in much the same way as the commercial catch cap is managed, i.e. the season is closed when the catch limit is reached. Depending upon how such an option were implemented there could be significant costs and administrative hurdles to be addressed.

It may also be reasonable to review the east coast catch share split between commercial and recreational fisheries as an element of future management direction. However, in the absence of policy guidance around fisheries allocation (or reallocation) in Tasmania any such determination would ultimately be a political decision. A re-allocation of a higher proportion of the catch share to the recreational fishery would ease the regulatory burden on the sector but would still need to ensure that recreational catches are effectively monitored and constrained within the revised catch share arrangements.

Although there are no simple solutions to the management of this shared fishery it is hoped that the current project will assist managers, recreational and commercial sectors in working proactively to meet the challenges.

Recommendations

The East Coast Stock Rebuilding Strategy was implemented as a ten-year plan (2013-2023) with the objective of rebuilding stocks in each of the east coast assessment areas to at least 20% of their unfished biomass. The primary instrument to achieve this has been to reduce and restrict catches from the region. Although achieving the catch target has proven challenging, there is evidence of stock rebuilding but without further management intervention it is unlikely that the rebuilding target will be achieved within the strategy's timeframe. Looking beyond 2023, it is also important to recognise that 20% unfished biomass represents an interim stock rebuild level and that a target in excess of 30% would be more in line with contemporary national/international fisheries management practice or standards.

Regionally, the relative contribution of the recreational harvest to the total catch (recreational plus commercial) has historically been highest off the east coast (Areas 1-3), typically accounting for ~15-30% of the total east coast catch prior to the implementation of the ECSRS (this compares with 7-8% of the total state-wide catch). Furthermore, in most years the east coast has attracted about 75% of the recreational lobster fishing effort, accounting for 60-70% of the recreational catch (by numbers), not only emphasising the significance of the region to the sector but highlighting that any future management decisions will need to be considered in a truly multi-sectoral context.

There is, therefore, a need to develop policy objectives that, in addition to resource sustainability and economic performance, take account of the social and community benefits of both recreational and commercial fisheries. Key elements of such a strategy will ideally include a resource sharing policy that incorporates principles for re-allocation (including conditions under which re-allocation or review of allocations is triggered) and a cost-effective and agreed monitoring framework for the recreational sector.

Extension and Adoption

A workshop between the project team and DPIPWE Marine Resources (16 attendees) was held on 6 March 2019 to consider the costs and benefits of short- and long-term management options for the East Coast Rock Lobster Fishery. The workshop considered what a future vision for the overall fishery could look like, with sustainability and social factors emerging as of highest importance. Threats and challenges to the East Coast fishery as well as potential management options and scenarios that formed the foundation of the current project were discussed and confirmed. The workshop recognised the need to develop clearer policy objectives for the rock lobster fishery in general and a strategic perspective for east coast stocks beyond 2023, noting that the current rebuilding objective of 20% unfished biomass was not an endpoint and that further rebuilding is desirable. Project updates, building on this workshop, were presented to the Recreational and the Crustacean Fishery Advisory Committees (RecFAC and CFAC) in March and April 2019.

A joint RecFAC and CFAC meeting to consider the management of the East Coast fishery was held on 20 June 2019, key project findings were presented and discussed by the stakeholder groups. The FACs have developed recommendations regarding preferences for the future management of the East Coast rock lobster fishery. Feedback from the joint FAC meeting has been considered in preparing the current project report.

Appendix 1: Project staff

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Appendix 2: Intellectual Property

The research relating to this project is for the public domain and the report and any resulting publications are intended for broad dissemination and promotion.

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Appendix 4: Recreational fisher survey questionnaire (phone)

RECREATIONAL LOBSTER FISHERY - 2018 EAST COAST MANAGEMENT SURVEY

Name: <From Database> Contact number: <From database> Licence: <From database>

I/viewer Initials: ☐☐

Call Details:Response Report

Day/Mth	Time	Result (C/NC/NA)	Appointments/other
..... /.....	.....	.....	.....……....
..... /.....	.....	.....	.....……....
..... /.....	.....	.....	.....……....
..... /.....	.....	.....	.....……....
..... /.....	.....	.....	.....……....
..... /.....	.....	.....	.....……....

Fully responding	1
Full refusal	2
Part refusal	3
Full non-contact	4
Part non-contact	5
Other non-response	6
Disconnect	7
Other (specify)	8

INTRODUCTION: **Good morning/etc. ..... from Institute for Marine and Antarctic Studies (University of Tasmania) .... we are conducting a survey of rock lobster fishers to assist with the management of the fishery ....** (I/VIEWER: ID LICENSEE; PERSONAL I'VIEW) **... and your licence number has been randomly selected … I was wondering whether I could ask you a few questions about your fishing and opinions about management ..** .(IF AGREEABLE) **…** T**his survey is voluntary and should take about 10 minutes. Your responses will be combined with those of others and all personal information will be treated in the strictest confidence.**

First some questions about your fishing experience:

Q1(a) **How many years have you been actively involved in recreational fishing**? (BEST ESTIMATE) ..**……..** ☐

(b) **(and) how many years have you done any kind of fishing/diving for lobster in Tasmania?** ..**……..** ☐

(c) **(and) do you fish with pots, rings and/or dive for lobster** (RECENT YEARS ONLY)

Pot	1
Ring	2
Dive	3

Q2(a) **On average, how many days a year would you normally expect to spend recreational fishing? ……** ☐

(b) (**and) on average, how many days (per year) would you normally expect to spend fishing/diving for lobsters (in Tasmania)? ……** ☐

(c**) (and) during this season (since Nov 2017) how many separate days did you actually go fishing/diving for lobsters (in Tasmania), whether you caught any or not?** (BEST ESTIMATE) **……**. ☐

(d) (IF Q2c NOT NIL) **(and) how many lobster did you personally catch and keep (this season)?** (BEST ESTIMATE) **……** ☐

SG3 IF FISHED IN Q2c GO TO Q4 OTHERWISE GO TO Q5

Q4 **(And) whilst fishing for lobster this season were you checked by the Marine Police at any time?**

Yes	1
No	2
UNSURE	3

Q5 (a) **Of the following regions, where do you usually fish for lobster?** (READ)

	Fished Y/N	% days
East and South East Coasts (Eddystone Pt to Whale Head/South East Cape)	**…….**	**…….**
North Coast (Eddystone Point to Woolnorth, including Bass Strait Islands)	**…….**	**…….**
West Coast (Woolnorth to Whale Head/SE Cape)	**…….**	**…….**

(b) (IF MULTIPLE IN Q5a) … **so what percentage or proportion of your lobster fishing days would you normally spent on the …… Coast, etc**

Q6 **When fishing for lobster do you do day trips from home (i.e. your primary residence), stay away at a holiday shack, hotel or camp site (**include on board boat**) or a bit of both?**

	Fish	Most
Home	1	1
Away	2	2
Both	3	

(IF BOTH) **Would you say <u>most</u> of your lobster fishing (i.e. days fished) is usually done based on day trips from home or whilst staying away from home?**

Q7 **From the following list, can you tell me what other types of fishing you have done over the past 12 months** (CIRCLE IF DONE)

	Done
Gamefishing (e.g. tunas, billfish, makos)	**…..**1
Deepwater bottom fishing (striped trumpeter, blue eye trevalla)	**…..**2
Coastal and estuary line fishing (e.g. flathead, Aus salmon, calamari)	**…..**3
Net fishing (graball, mullet or beach seine)	**…..**4
Diving for scallops, abalone	**…..**5
Flounder spearing	**…..**6
Freshwater fishing	**…..**7
Any other (specify) **……**	**…..**8

Q8 (**Now) compared to <u>other types of outdoor activities</u> you participate in, would you say fishing is ….**

Your most important outdoor activity	**…..**1
Your second most important activity	**…..**2
Only one of many outdoor activities that you do	**…..**3
UNSURE	…..4

Q9 **And compared to <u>other types of fishing</u> you participate in, would you say fishing/diving for lobster is ….**

Your most important type of fishing	…..1
Your second most important type of fishing	…..2
Only one of many types of fishing that you do	…..3
UNSURE	…..4

Q10 **How often are the lobsters you retain used in each of the following ways …**
(READ FROM LIST BELOW) **… would you say mostly, occasionally or rarely/ never**

		Mostly	Occasionally	Rarely/Never
a)	**Eaten fresh by your household/family**	1	2	3
b)	**Frozen for later use by your household/family**	1	2	3
c)	**Given to another household/family**	1	2	3
d)	**Exchanged for another product or service**	1	2	3

Q11 **During this year's fishing season areas of the east coast were closed to lobster fishing because of the impacts of a toxic algal bloom (**PARALYTIC SHELLFISH TOXIN**). Did these events have any influence on <u>where or how often</u> you went fishing/diving for lobster this season?**

Yes	1
No/not really (*go to Q12*)	2
Unsure (*go to Q12*)	3

IF YES …. **in what ways** (PROBE AND RECORD)

……

Q12**(a) Prior to the first major biotoxin outbreak in 2012, did you eat the lobster's liver, commonly known as the "mustard or tomalley"?**

Yes	1
Occasionally/sometimes	2
No (Go to Q13)	3
UNSURE (Go to Q13)	4

(b) **And as a consequence of these biotoxin events have you changed which parts of the lobster you now eat?**

Yes	1
No	2
UNSURE	3

Q13(a) **Do you think the government did enough to <u>communicate</u> information about the public health risks and closures?**

Yes (*go to Q14*)	1
No/not really	2
Unsure (*go to Q14*)	3

(b) **Do you have any suggestions as to how they might have communicated the information in more effective way?** (PROBE AND RECORD)

……

Q14 **I'm now going to read some statements about lobster fishing. As I read each one, please tell me whether you agree or disagree with the statement. Firstly ...** (READ OUT EACH AND PROBE FOR AGREE/DISAGREE STRONGLY OR MILDLY? NA IF UNSURE OR NOT RELEVANT)

	SA	MA	MD	SD	NA
a) **If I couldn't go fishing or diving for lobster I'm not sure what I would do**	1	2	3	4	5
b) **Fishing or diving for lobster is one of the most satisfying things I do**	1	2	3	4	5
c) **I consider myself to be expert at catching lobster**	1	2	3	4	5
d) **If I couldn't go lobster fishing where I usually go because of biotoxin closures I would travel to another zone to fish for lobster**	1	2	3	4	5
e) **I would rather catch one large lobster than two just legal sized lobster**	1	2	3	4	5
f) **Being able to eat lobster I've caught is an important social occasion**	1	2	3	4	5
g) **When I go lobster fishing I am not satisfied unless I catch at least one lobster**	1	2	3	4	5
h) **If the daily bag limit was reduced to one lobster I probably wouldn't bother fishing for lobster**	1	2	3	4	5
i) **An unexpected closure of the lobster fishery due to high biotoxin levels wouldn't influence my decision to still go fishing or diving for other species in that area**	1	2	3	4	5
j) **I would still undertake a similar number of fishing trips to the East Coast even if I couldn't go fishing for diving for lobster there.**	1	2	3	4	5

SG15 If EAST AND SOUTH EAST COAST FISHER AT Q5 GO TO Q16 OTHERWISE GO TO Q17.

Q16 **Now some questions about the management of the fishery.**

In 2013 the government implemented a strategy to build east coast lobster stocks back to a healthy level. A key to this strategy is limiting the amount of lobster caught (each year) by constraining the allowable commercial catch to a catch-cap and various measures applying to the recreational sector. These include reductions in the daily bag limit, now 2 per day, a delay in the opening of the season and the winter closure (from May on).

The Fisheries Minister also recommended a maximum recreational catch of about 42 tonnes for the east coast. Recent surveys suggest that the management changes may not be sufficient to constrain the catch to this level, thus we would like to get your opinion on a range of other possible options.

Firstly I'd like your thoughts on how effective you think each measure if applied <u>to the Eastern Region</u> would be in restricting catches and then whether you would be generally supportive or opposed to the option.

		Effective	Supportive
a) **Reduce the daily bag limit to one per day.**	Yes	1	1
	No/not really	2	2
	Unsure	3	3
b) **Increase the minimum size limit, meaning more of the catch is released**	Yes	1	1
	No/not really	2	2
	Unsure	3	3
c) **Further reduce the length of the season (in the Eastern Region).**	Yes	1	1
	No/not really	2	2
	Unsure	3	3
The current season is about 24 weeks (5 ½ months), what do you think would be the minimum acceptable season length? (RECORD)	……		
d) **Introduce a maximum East Coast seasonal catch limit for each licence-holder** (e.g. catch tags)**.**	Yes	1	1
	No/not really	2	2
	Unsure	3	3
How many lobsters would you consider as acceptable for such a seasonal catch limit? (RECORD)	……		
e) **Limit the number of licences that have access to the Eastern Region for lobster** (e.g. by a ballot or lottery)**.**	Yes	1	1
	No/not really	2	2
	Unsure	3	3
f) **Reduce the commercial catch allowance to offset any increase in recreational catches.**	Yes	1	1
	No/not really	2	2
	Unsure	3	3
(And) would you be generally willing to pay a small fee to make this happen (e.g. to buy back catch quotas)	Yes	1	
	No/not really	2	
	Unsure	3	

Q17 **We are also interested in opinions about compliance with the fisheries regulations. I'm going to read out some types of illegal fishing activity. As I read each one, please tell me how common a problem you think it is. Firstly, ...** (READ EACH REASON AND ANSWER CATEGORIES)

	Very common	Quite common	Not very common	Not at all common	UNSURE
Out of season fishing for lobster	1	2	3	4	5
Retaining more than the daily bag limit	1	2	3	4	5
Retaining undersize lobster	1	2	3	4	5
Pulling other fisher's gear and stealing their catch	1	2	3	4	5
Catching lobsters for other licence-holders in the fishing party	1	2	3	4	5
Fishing for lobsters without a licence	1	2	3	4	5

In your opinion, what proportion of recreational fishers do you think may have kept more than the bag limit in the last 12 months? [0-100%] _____%

Q18 **Thank you for helping with this survey, your answers will now be combined with those of others and your identity will remain confidential.**
(IF WEST OR NORTH COAST ONLY FISHERS THANK AND TERMINATE)

In order to better understand preferences for management we are inviting participants into a second phase which can be done on-line or by mail. Would you be interested in contributing to that study?

IF YES **Would it be more convenient for us to send you a link to an online survey or to mail you a copy of the survey.** OTHERWISE THANK AND TERMINATE

Follow up survey	Yes (online)	1
	Yes (mail)	2
	No	3

IF ON-LINE **Do you have an email address that we could send you the link?**

……

IF MAIL **Can I get a mailing address so we can send you the survey?**

……
……
……

We hope to get details of that survey to you within the next few weeks.

THANK AND TERMINATE

Appendix 5: Discrete choice experiment survey (example)

Instructions

The purpose of this survey is to evaluate fishers' preferences for different combinations of fisheries regulations for the Eastern Region of the lobster fishery.

East coast lobster stocks have been in decline and as a consequence the Tasmanian government has implemented a ten-year strategy to rebuild them to healthy levels. A key to this strategy is limiting the amount of lobster caught each year off the east coast by both commercial and recreational fishers. The government has already implemented some different measures to achieve this for the recreational sector, for example a reduction in the daily bag limit (now 2 per day) and a shortening of the season in the Eastern Region.

In this survey, we would like to get your input on the implementation of different measures to limit/ control recreational harvest to ensure that the stocks continue to rebuild. We will present you with a series of management scenarios and ask you to indicate your preferred option. In addition, we are interested in understanding your perceptions about general compliance with regulations in the fishery and there will be a few questions on this.

Basic Demographics

First we have some questions about your fishing experience and basic demographics for our records.

Q1. How many years have you been actively involved in recreational fishing? (best estimate)

☐ years

Q2. How many years have you been fishing/ diving for lobster in Tasmania?

☐ years

Q3. Do you fish with pots, rings and/or dive for lobster? (Please tick- You may select more than one box.)

Pot ☐ Ring ☐ Dive ☐

Q4. On average, how many days (per year) would you normally expect to spend fishing/diving for lobsters in Tasmania?

☐ days

Q5. How old are you? (Please tick)

<20 ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60-69 ☐ 70+ ☐

Q6. Postcode of your residence?

☐☐☐☐

Section A Instructions

This section is about your preferences for the management of the Eastern Region recreational rock lobster fishery. We want you to think about the types of regulations and compliance management, keeping in mind the stock rebuilding strategy that is in place and the potential for a change in management to achieve this rebuilding objective.

You will be asked about 6 different scenarios with different management options. For each question we are asking you to compare the options and decide which option you would chose to renew your licence for or whether you would choose not to renew your licence.

The management scenarios will vary in penalties for non-compliant acts and regulations for bag limits, season length and individual seasonal catch limit. Individual seasonal limit is the maximum number of lobster an individual licence holder would be permitted to retain during the season, daily bag limits would still apply. The minimum size limits for females will also vary in the management scenarios, which may influence catch rates. Any size limit scenarios would apply to both recreational and commercial fishers. Assume that all other regulations will remain as they are in 2018.

Scenario 1 (out of 6)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

You should base your preferences considering your actual fishing experiences, for instance consider these options in relation to how often you go (or would hope to go) fishing/diving for lobster, your usual catch rates and the sizes of the lobsters you normally catch.

Management feature	Option A	Option B	Option C
Daily bag limit	2/ day	2/ day	I wouldn't renew my licence
Season length	8 weeks	16 weeks	
Maximum seasonal catch limit per licence holder	12 lobsters/ season	8 lobsters/ season	
Size limit for females	Increase by 10mm	As is	
Penalties for non-compliant acts	As is	Increase by 50%	

A1a) Which of these options do you prefer? (Please tick)

Option A ☐ Option B ☐ Option C ☐

A1b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)

Option A ☐ Option B ☐

Scenario 2 (out of 6)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

Management feature	Option A	Option B	Option C
Daily bag limit	1 / day	2 / day	I wouldn't renew my licence
Season length	24 weeks	24 weeks	
Maximum seasonal catch limit per licence holder	24 lobsters/ season	24 lobsters/ season	
Size limit for females	As is	Increased by 10mm	
Penalties for non-compliant acts	As is	Increased by 50%	

A2a) Which of these options do you prefer? (Please tick)

Option A ☐ Option B ☐ Option C ☐

A2b) If you chose Option C above, from the remaining two options, which do you prefer?

Option A ☐ Option B ☐

Scenario 3 (half way)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

Management feature	Option A	Option B	Option C
Daily bag limit	1 / day	3 / day	I wouldn't renew my licence
Season length	24 weeks	8 weeks	
Maximum seasonal catch limit per licence holder	20 lobsters/ season	24 lobsters/ season	
Size limit for females	Increased by 10mm	As is	
Penalties for non-compliant acts	As is	Increased by 50%	

A3a) Which of these options do you prefer? (Please tick)

Option A ☐ Option B ☐ Option C ☐

A3b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)

Option A ☐ Option B ☐

Scenario 4 (out of 6)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

Management feature	Option A	Option B	Option C
Daily bag limit	3 / day	1 / day	I wouldn't renew my licence
Season length	16 weeks	8 weeks	
Maximum seasonal catch limit per licence holder	8 lobsters/ season	16 lobsters/ season	
Size limit for females	As is	Increased by 10mm	
Penalties for non-compliant acts	Increased by 50%	As is	

A4a) Which of these options do you prefer? (Please tick)

Option A ☐ Option B ☐ Option C ☐

A4b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)

Option A ☐ Option B ☐

Scenario 5 (out of 6)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

Management feature	Option A	Option B	Option C
Daily bag limit	2 / day	2 / day	I wouldn't renew my licence
Season length	8 weeks	24 weeks	
Maximum seasonal catch limit per licence holder	20 lobsters/ season	12 lobsters/ season	
Size limit for females	Increased by 10mm	As is	
Penalties for non-compliant acts	Increase by 50%	As is	

A5a) Which of these options do you prefer? (Please tick)

Option A ☐ Option B ☐ Option C ☐

A5b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)

Option A ☐ Option B ☐

Scenario 6 (final one)

Please compare the following three options for the management of the rock lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

Management feature	Option A	Option B	Option C
Daily bag limit	1 / day	2 / day	I wouldn't renew my licence
Season length	16 weeks	8 weeks	
Maximum seasonal catch limit per licence holder	40 lobsters/ season	40 lobsters/ season	
Size limit for females	Increased by 5mm	Increased by 5mm	
Penalties for non-compliant acts	Increased by 50%	As is	

A6a) Which of these options do you prefer? (Please tick)

Option A ☐ Option B ☐ Option C ☐

A6b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)

Option A ☐ Option B ☐

Section B

We are now going to ask you some questions about the survey you have just completed. Please answer these questions by putting a tick (√) in the appropriate box for each question.

B1. Please indicate how certain you were of the answers you gave to the management choices

Not certain at all	
Not really certain	
Quite certain	
Very certain	

B2. Did you find some of the choices unrealistic?

Yes	
No	
Unsure	

B3. Did you find it difficult identifying your preferred option for some of the choices?

Yes, very difficult	
Yes, difficult	
Yes, a bit difficult	
No, it was easy	

B3.1 If you found it difficult why was this? You may select more than one box.

The choices were confusing	
The choices were too complex	
I did not have sufficient information or knowledge to make such choices	
Scientists or managers should make such choices, not me	
The choices were not relevant to me	

B4. Did you ignore any of the five management features when making your choices?

Yes – I consistently ignored one or more of the features in making my choices	
Sometimes- I occasionally ignored one or more of the features in making my choices	
No — I did not consistently ignore any of the features in making my choices	

B4.1 If you ignored any of the management feature(s), which did you ignore? You may select more than one box.

Penalties for non-compliant acts	
Daily bag limit	
Season length	
Seasonal catch limit per licence holder	
Size limit for females	

Section C

Thank you for your participation so far. We are interested in understanding your perceptions about general compliance with regulations in the fishery. We are asking you to indicate (by ticking your answer in the appropriate box) how strongly you agree or disagree with each of the following statements the following questions on a scale from strongly agree to strongly disagree.

		Strongly Agree	Agree	Disagree	Strongly Disagree	I don't know
C1	Fishers who keep more than the bag limit do not believe they will get caught.					
C2	Fishers who keep more than the bag limit do not care about conservation.					
C3	Fishers who keep more than the bag limit do so as an act of protest.					
C4	It is reasonable for fishers who fish a few days a year to keep an extra rock lobster or two on a given day.					
C5	Any extra catch taken by recreational fishers is unlikely to have a detectable impact on the lobster populations, compared with the commercial fishery					
C6	The current bag limit allows everyone a "fair or equal share" of the benefits and resources available on the East Coast of Tasmania.					
C7	I know some fishers who have kept more than the bag limit in the last 12 months.					
C8	The social shame of being caught would prevent me from keeping more than the bag limit.					
C9	I care whether my friends and family would disapprove if I kept more than the bag limit.					
C10	I care whether people I don't know would disapprove of me if I kept more than the bag limit.					
C11	Current fines and penalties for fisheries breaches are not high enough to be a real deterrent.					
C12	The chance of being caught with more than the possession limit is so small that it is not much of a deterrent.					
C13	I feel obliged to obey the fisheries regulation.					
C14	The risk of being fined would prevent me from keeping more than the bag limit.					
C15	The risk of getting my boat, fishing equipment, or other property confiscated would prevent me from keeping more than the bag limit.					

C16. In your opinion, what proportion [0-100%] of recreational fishers do you think;

may have kept more than **the daily bag limit** of Lobster during the last 12 months? _____%
may have kept more than **the possession limit** of Lobster during the last 12 months? _____%
may have kept more than **the boat limit** of Lobster during the last 12 months? _____%

Finally, do you have any other comments regarding the management of the fishery or about this survey:

Please indicate by ticking the box if you would NOT like your responses to this survey to be linked to the information you provided in the phone survey;

I would not like my data to be linked ☐

Thank you for your participation

Appendix 6: Commercial fisher survey questionnaire

Dr. Justin Rizzari
Crustacean Fisheries Scientist
Institute for Marine and Antarctic Studies
University of Tasmania
Phone: 0450 551 087
Email: Justin.Rizzari@utas.edu.au

Rebuilding Southern rock lobster Stocks on the East Coast of Tasmania: Informing Options for Management

Please read this first:

In 2013 the Tasmanian government implemented a strategy to rebuild the east coast rock lobster stocks back to healthy levels of at least 20% of the unfished biomass by 2023. A key to this strategy is limiting the amount of lobster caught from the east coast to a defined maximum level based on scientific advice. Under this strategy the commercial east coast catch is limited by a regional catch cap which is monitored within the quota management system. As stocks rebuild and catch rates increase, it is anticipated that there will be increased effort from the commercial sector resulting in the catch cap closing earlier each year. For example, this year the catch cap closed at the end of January – 4.5 weeks before the end of the quota year – despite biotoxin closures.

As a commercial fisher, we invite you to participate in a voluntary survey to assess your attitudes and perceptions regarding the management of the east coast fishery and the social and economic importance of being able to access the east coast. This survey is being conducted by the Institute for Marine and Antarctic Studies (University of Tasmania) and is funded by the Fisheries Research and Development Corporation and supported by DPIPWE and the TRLFA. The survey is voluntary and expected to take between 10-15 minutes.

By submitting your survey response, you are providing your consent to participate in this study. Please be assured, all personal identifying information will be treated in the strictest confidence and will be removed from the databases at the completion of the study. In addition, any reports will involve combined information and thus any comments or responses will not be individually identifiable. If you have any questions about the study feel free to contact me, Justin Rizzari, on 0450 551 087 or email Justin.Rizzari@utas.edu.au. Alternatively, you may contact other members of the research team; Dr. Jeremy Lyle (Jeremy.Lyle@utas.edu.au) or Dr. Klaas Hartmann (Klaas.Hartmann@utas.edu.au).

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have any concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on +61 3 6226 6254 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H17297.

In anticipation, I would like to sincerely thank you for your time and effort in contributing to this important study.

Warm Regards,

Justin Rizzari

PART A OPERATING CHARACTERISTICS

Q1) In the last quota year (1 March 2017 – 28 February 2018) how many quota units did you own?

Q2) In the last quota year (1 March 2017 – 28 February 2018) how many quota units did you lease in?

Q3) At which port did you land most of your lobster catch during the last quota year (1 March 2017 – 28 February 2018)?

Q4) What is the length of your fishing vessel in metres?

Q5) How many pots are you licensed to carry on your vessel?

Q6) In the last quota year (1 March 2017 – 28 February 2018) what percentage of your catch came from the east coast stock rebuilding zone (Eddystone Pt. to Tasman Head, Bruny Island)? Please choose only one response.

- ☐ 100%
- ☐ More than 75%
- ☐ 25-75%
- ☐ Less than 25%
- ☐ 0%

PART B PERCEPTIONS ON YOUR LEVEL OF DEPENDENCE REGARDING THE EAST COAST STOCK REBUILIDING ZONE CATCH CAP

As stocks rebuild along the east coast it is anticipated that this will attract increased effort from the commercial fishers resulting in the catch cap being reached earlier each year. Below you will find some statements regarding fishing within the east coast stock rebuilding zone (Eddystone Pt. to Tasman Head, Bruny Island) as it pertains to the catch cap being reached. Please rate your level of agreement or disagreement with each statement.

If I couldn't fish within the east coast stock rebuilding zone because the catch cap had been reached, and I still had quota left, then …..

Tick one box for each statement. If the statement doesn't apply to you or you are unsure, tick 'N/A'

	Strongly agree	**Mildly agree**	**Mildly disagree**	**Strongly disagree**	**N/A**
Q7) … I would likely change my home port or where I land my catch to reduce travel to and from open fishing areas.	☐	☐	☐	☐	☐
Q8) … I would travel to another area to fish my uncaught quota.	☐	☐	☐	☐	☐
Q9) … I would consider leasing out my uncaught quota.	☐	☐	☐	☐	☐
Q10) … I would consider other types of fishing (e.g. scalefish) off the east coast.	☐	☐	☐	☐	☐
Q11) … I would have a hard time maintaining my business.	☐	☐	☐	☐	☐

Q12) If you are unable to travel such areas to fish in other zones, what factors might affect your ability to travel to other areas? Please select all that apply.

☐ N/A – I am able to travel further afield

☐ Not economically viable

☐ MAST limitations (e.g. vessel size)

☐ Family reasons

☐ Health reasons

☐ Lack of local knowledge

If none of the above apply then please elaborate further below.

PART C PERCEPTIONS ON CATCH RATES INCREASING IN THE EAST COAST STOCK REBUILIDING ZONE

Catch rates within the east coast stock rebuilding zone (Eddystone Pt. to Tasman Head, Bruny Island) are predicted to increase substantially. For the commercial sector, the east coast is expected become an increasingly more attractive area to fish and thus taking the catch cap is could become more competitive in a "race-to-fish" type scenario.

Below you will find some statements regarding your perceptions on expected increases in catch rates, and competition with other commercial fishers within the catch cap area. Please rate your level of agreement or disagreement with each statement.

Tick one box for each statement. If it doesn't apply to you or you are unsure, tick 'N/A'

	Strongly agree	**Mildly agree**	**Mildly disagree**	**Strongly disagree**	**N/A**
Q13) If east coast catch rates increased substantially as predicted, then I would consider fishing within the east coast stock rebuilding zone more often and would possibly lease in additional quota.	☐	☐	☐	☐	☐
Q14) I would feel annoyed if more commercial fishers started fishing within the east coast stock rebuilding zone.	☐	☐	☐	☐	☐
Q15) I am concerned that as stocks continue to improve on the east coast that competition from other commercial operators will put further pressure on the viability of my fishing operation.	☐	☐	☐	☐	☐

Q16) If you currently do not fish within the east coast stock rebuilding zone, or do so very infrequently, what key factors would make fishing within the east coast stock rebuilding zone more attractive?

☐ Improved east coast catch rates

☐ Declining catch rates in other areas

☐ Proximity to ports

☐ Increase in market prices

Other reasons (please specify below)

PART D PERCEPTIONS ON MANAGEMENT OF THE EAST COAST STOCK REBUILDING ZONE

Management of the east coast commercial rock lobster fishery is subject to a catch cap which is monitored within the quota management system. In 2016, the Minister determined the notional maximum catch limit for the east coast rock lobster stock rebuilding zone be split between commercial and recreational fisheries 79% and 21%, respectively.

Below you will find some statements regarding your perceptions on the management of the east coast stock rebuilding zone. Please rate your level of agreement or disagreement with each statement.

Tick one box for each statement. If it doesn't apply to you or you are unsure, tick 'N/A'

	Strongly agree	**Mildly agree**	**Mildly disagree**	**Strongly disagree**	**N/A**
Q17) The application of the east coast catch cap is an effective management measure for achieving the stock rebuilding goals for the commercial fishery.	☐	☐	☐	☐	☐
Q18) Application of a catch cap is a fair and equitable way to manage catches taken by the commercial operators.	☐	☐	☐	☐	☐
Q19) Misreporting of the zone that catches are taken from is a minor problem within the commercial sector.	☐	☐	☐	☐	☐
Q20) There are sufficient marine police checks for commercial unloadings to ensure compliance by commercial operators of the catch cap.	☐	☐	☐	☐	☐
Q21) The split of the east coast catch target between commercial (79%) and recreational (21%) sectors is fair and reasonable for both sectors.	☐	☐	☐	☐	☐

Q22) If you disagreed with any of the above statements can you please indicate the main reasons for your disagreement?

Q23) Would you be generally supportive of management measures that might slow down the rate at which the commercial catch cap is reached?

☐ Yes
☐ No
☐ Unsure

Q24) Do you think the following measures would be effective at slowing down the rate at which the commercial east coast catch cap is reached, thus reducing competition within the commercial fishing sector? Also, which of the following measures would you support. **Please note that the management measures outlined below are not proposals, but only hypothetical scenarios.**

Tick one box for whether you think the management measure is effective and one box for whether you support that management measure. If it doesn't apply to you or you are unsure, tick 'Unsure'

M**easure**	**Effective Rating**	**Support rating**
Split quota into east and west quota units	Effective ☐ Not very effective ☐ Not at all effective ☐ Unsure ☐	Yes ☐ No ☐ Unsure ☐
Increase the minimum size limit	Effective ☐ Not very effective ☐ Not at all effective ☐ Unsure ☐	Yes ☐ No ☐ Unsure ☐
Additional seasonal closures	Effective ☐ Not very effective ☐ Not at all effective ☐ Unsure ☐	Yes ☐ No ☐ Unsure ☐
Reduction in the maximum number of pots per vessel that can be used on the east coast	Effective ☐ Not very effective ☐ Not at all effective ☐ Unsure ☐	Yes ☐ No ☐ Unsure ☐
Priority access be given to operators with a proven history of fishing the east coast region	Effective ☐ Not very effective ☐ Not at all effective ☐ Unsure ☐	Yes ☐ No ☐ Unsure ☐
Leave industry to work it out themselves, for example through a voluntary code of conduct	Effective ☐ Not very effective ☐ Not at all effective ☐ Unsure ☐	Yes ☐ No ☐ Unsure ☐

Q25) If you have any other options, or suggestions, for effective measures to slow down the rate at which the catch cap is reached can you please elaborate?

PART E INFORMATION ABOUT YOU

Q26) What is your age?	☐ years
Q27) How many years have you worked in the commercial rock lobster fishery?	☐ years
Q27) Where do you live?	☐ Town (nearest town if in rural area) ☐ post code
Q29) Did you choose to live in this location because of your fishing activities? (e.g. so you could fish from a place close to where you live)	☐ Yes ☐ No

PART F FURTHER COMMENTS

Q30) Please provide any additional comments that you have regarding the management of the east coast stock rebuilding zone.

Thank you for completing this survey

Appendix 7: DCE regression results.

Table 1. Conditional logit model on discrete choice experiment data for different fishing modes

	All fishers	Pot	Dive	Multi
Bag limit	0.517	0.502	0.433	0.573
	(0.000)	(0.000)	(0.003)	(0.000)
Season length	0.246	0.280	0.207	0.205
	(0.000)	(0.000)	(0.111)	0.011
Maximum seasonal catch limit	0.044	0.059	0.164	-0.023
	(0.072)	(0.085)	(0.014)	(0.574)
Size limit for females	0.076	0.061	-0.008	0.125
	(0.209)	(0.468)	(0.961)	(0.229)
Penalties for non-compliant acts	0.103	0.102	0.057	0.131
	(0.297)	(0.460)	(0.833)	(0.433)
Constant	-1.979	-2.041	-2.045	-1.864
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	2,574	1,314	342	918
Number of subjects	143	72	19	52
Log-likelihood	-1459.7	-740.7	-193.7	-521.7
McFadden's pseudo-R^2	0.109	0.114	0.110	0.107
AIC	2931.3	1493.5	399.39	1055.4

Note: This table reports the estimates of the coefficients and *p*-values in parentheses from different model specifications.

Table 2. Conditional logit model on discrete choice experiment data for different avidity levels

	All fishers	Low Avidi	Mid Avidi	High Avidi
Bag limit	0.517	0.616	0.437	0.517
	(0.000)	(0.000)	(0.000)	(0.000)
Season length	0.246	0.339	0.193	0.171
	(0.000)	(0.000)	(0.023)	(0.068)
Maximum seasonal catch limit	0.044	0.109	0.027	-0.044
	(0.072)	(0.004)	(0.523)	(0.374)
Size limit for females	0.076	-0.067	0.124	0.298
	(0.209)	(0.475)	(0.270)	(0.010)
Penalties for non-compliant acts	0.103	0.186	-0.184	0.320
	(0.297)	(0.223)	(0.299)	(0.106)
Constant	-1.979	-2.395	-1.657	-1.877
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	2,574	1,080	828	666
Number of subjects	143	60	46	37
Log-likelihood	-1459.7	-582.5	-486.7	-377.7
McFadden's pseudo-R^2	0.109	0.153	0.077	0.109
AIC	2931.3	1176.9	985.34	767.43

Note: This table reports the estimates of the coefficients and *p*-values in parentheses from different model specifications.