FRDC
FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Recreational Southern Rock Lobster tagging program:

assessing current data and modelling assumptions and approaches to establish a robust estimate.

Karlie McDonald, Jeremy Lyle, Klaas Hartmann and Toby Jeavons

November 2021

FRDC Project No **2019/075**

ISBN 978-1-922708-10-6 (print) 978-1-922708-11-3 (electronic)

Recreational Southern Rock Lobster tagging program: assessing current data and modelling assumptions and approaches to establish a robust estimate.

FRDC Project No 2019/075

2021

Researcher Contact Details

Name:	Karlie McDonald
Address:	15-22 Nubeena Crescent, Taroona, Tasmania.
Phone:	
Fax:	
Email:	Karlie.mcdonald@utas.edu.au

FRDC Contact Details

Address:	25 Geils Court
	Deakin ACT 2600
Phone:	02 6122 2100
Email:	frdc@frdc.com.au
Web:	www.frdc.com.au

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

Table of Contents

List of Tables

List of Figures

Acknowledgments

The authors would like to thank the recreational fishers who participated in the fisher surveys and the participants of the Recreational Rock Lobster Tagging Program Steering Committee who met between August 2020 and July 2021 to provide feedback on proposed revisions to the electronic catch reporting program. The authors thank Fiona Ewing for administration and management of the fisher survey and Shirley Lines and Josephine French for their efforts as the survey interviewers. We would like to acknowledge the generous support by the Fisheries Research and Development Corporation (FRDC) and the Fisheries and Aquaculture Centre at the Institute of Marine and Antarctic Studies (IMAS) without which this project would not have been possible.

Abbreviations

VFA	Victorian Fisheries Authority
VicRLTag	Victorian Recreational Rock Lobster Tagging Program
App	Electronic Application
TACC	Total Allowable Commercial Catch
ABS	Australian Bureau of Statistics
SA4	Statistical Area 4
CPUE	Catch per Unit Effort
CL	Carapace Length
RL	Rock Lobster
AB	Abalone
IMAS	Institute for Marine and Antarctic Studies

Executive Summary

The Victorian Recreational Rock Lobster Tagging Program, which commenced in July 2017, requires all recreational fishers harvesting or attempting to harvest rock lobster to register an account with the Victorian Fisheries Authority (VFA), obtain tags and report the fate of the tags. The Victorian recreational rock lobster app (VicRLTag) was developed as a web-based platform and for iPad, iPhone, and Android devices to assist with this mandatory reporting of recreationally caught rock lobster from Victorian waters. This project assesses options for streamlining and improving the current electronic reporting process (VicRLTag app) based on an evaluation of the first three years of the Victorian Recreational Rock Lobster Tagging Program.

The Victorian Recreational Rock Lobster Tagging Program is subject to data inaccuracies and biases. These include recall bias, non-response bias and inaccurate reporting. The features and data variables implemented can reduce the influence of biases on data accuracy of the program, such as limiting response options to reduce input errors. When considering which new features and variables to implement into VicRLTag trade-offs need to be made between a range of factors including the utility of the new features, over-complicating the app, and the cost of implementation. Focus should be given to features and variables that are directly related to management objectives, improve data accuracy and/or increase user participation.

Objectives

The objectives of this project are:

1. Outline the current Victorian Recreational Rock Lobster Tagging Program App (VicRLTag App).
2. Assess app features that are available or being developed for recreational catch reports that could be integrated into a new version of the VicRLTag app. This includes discussion of a selection of other recreational catch reporting apps that inform management decision-making.
3. Identify and evaluate biases that may affect the data accuracy of electronic catch reporting programs and the potential influence of these biases on the VicRLTag App.
4. Present recommendations for consideration by the Victorian Fisheries Authority during the further development of the VicRLTag App in the 2020/21 season.

Methodology

This study consists of four major components:

1. An evaluation of the current VicRLTag app and recreational tagging program, including obtaining fisher feedback at the Recreational Rock Lobster Tagging Program Steering Committee provided at meetings between August 2020 and July 2021 that guided the development of the project.
2. A review of recreational catch reporting apps including the features and reporting fields. This encompassed interviews with leaders of a selection of catch reporting programs that provide insights into lessons learnt and cost-benefits of different app features and implementation strategies.
3. Three fisher surveys were conducted:
    a. An initial survey to obtain feedback from recreational fishers on the Recreational Rock Lobster Tagging Program, demographic information on the participants in the fishery and the fishing behaviour of survey participants.
    b. A diary survey to obtain additional catch, effort and catch rate information which was conducted in parallel to the start of the 2020/21 season.
    c. A wrap-up survey that tested the appeal of potential app revisions on survey participants and obtained feedback on possible changes to the reporting program.
4. An assessment of biases that can influence catch reporting apps.

The information collected from the above studies were used to develop recommendations for the revision of the VicRLTag app and the Victorian Recreational Rock Lobster Reporting Program more broadly.

Key Findings

There are numerous apps available for recreational fishers to voluntarily record catch or report catch to management as required. Integrated in the vast number of catch reporting apps are wide-ranging features that increase the appeal through gamification or enhancing the reporting experience for fishers. We identified app features, such as trip-based reporting, that could be integrated into a revised VicRLTag app that focus on increasing the likelihood of achieving the management goals to accurately quantify recreational catch, effort, and catch rate. The three key functions of app features that promote increased catch reporting are:

- Incentivisation – encouragement for reporting through benefits provided to fishers, such as access to personal catch statistics.
- Communication – the establishment of two-directional communication between stakeholders and mechanisms to provide feedback fishers
- Education – promotion of the importance of the information provided for the sustainable management of the fishery and benefit to the recreational sector.

A revised VicRLTag app can take advantage of the opportunities to improve data accuracy that were identified in this study, such as implementing a hail in/out trip reporting process to replace physical tags while still allowing provisions for meaningful compliance checks. The inclusion of zero catch reporting (fishing trips where no catch was obtained) would improve the robustness of CPUE calculations which have been inflated in previous seasons due to only data from successful fishing trips being included. Another improvement to data accuracy could be achieved through promoting the accurate measuring of lobster length, rather than the gauges commonly used by recreational fishers interviewed in our fisher surveys.

The global perspectives obtained from interviews with international catch reporting programs provided insights into the cost-benefit of potential app features and implementation strategies of a revised VicRLTag, including a simple and easy to use app design that reduces time demands on fishers. The international programs interviewed emphasised the importance of to continuously incentivise and promote app up-take and use or have complementary compliance regulations to increase the reporting rate. At the launch of an app, it is important to have technical support readily available to resolve user issues before fishers lose interest or are discouraged by difficulties using the app.

Fisher surveys revealed that the Covid-19 pandemic impacted on opportunities for many recreational fishers to fish in the 2019/20 and 2020/21 seasons. Catch reports by diary survey participants closely matched the reports to VicRLTag with the slight variations detected likely attributed to recall error. Recreational fishers surveyed were most attracted to incentives that increased feedback and generally supported a tightening of compliance regulations to report within 48 hours of obtaining a catch. While recreational fishers acknowledge the importance of collecting information on zero catch fishing trips, the majority of survey participants wanted the reporting of zero catch fishing trips to be voluntary.

Recommendations

A focus of the revision of the VicRLTag app should be to increase reporting rate from the 24% of recreational fishers that reported catch in the 2018/19 season and increase the accuracy of catch, effort and catch rate data. App features that recommended as a high priority for inclusion in a revised VicRLTag app include offline reporting for when mobile reception is unavailable, automatic time and date stamps to reduce the reporting demands on fishers and geolocation of catch locations.

The revision of the VicRLTag app provides an opportunity for the inclusion of new reporting variables to fill information gaps that existed in the original version of the app. For example, the CPUE in VicRLTag was higher than the diary survey as the data reported to VicRLTag only included successful fishing trips and was therefore inflated. The reporting of zero catch fishing trips in VicRLTag would provide a more accurate measure of effort and catch rate. In addition, the reporting of target species and the fisher's experience in fishing for rock lobster in Victoria can provide valuable context to interpreting reported catch data.

Implementation of the revised rock lobster catch reporting program and VicRLTag app should include seven key features:

1. The identification of 5–9 key variables (questions) for recreational fishers to respond to.
2. A simplistic design targeted to the audience and purpose of the app.
3. Compliance regulations that complement and support the objectives of the program.
4. A process for validation of the data reported through the recreational catch reporting program.
5. Readily available technical support to promptly resolve fisher issues.
6. A plan for providing data analysis and feedback to fishers.
7. Communication strategies for highlighting the use and importance of the data in decision-making.

1. Introduction

The aim of electronic reporting is to provide more accurate and timely data on fishing catch, effort and catch rate. It has the potential for fewer reporting stages than paper-based log reporting and to be simpler and cheaper than comprehensive recall surveys. Recreational fisheries surveys have previously provided important information to monitor catch rates and manage fisheries, particularly in cases where studies are conducted with an inter-annual timestep rather than a once-off study (e.g., Lyle et al. 2019, Gutowsky et al. 2013). These surveys of recreational fisheries can provide extensive information, however, are also costly and subject to time delays in obtaining and analysing information.

Smartphone applications (apps) for recreational fishers provide an opportunity to obtain high frequency, near-real time, and extensive catch data in situations where data is traditionally limited if minimum standards for data collection are in place (Venturelli et al. 2016). Hancock (2012) identified over 100 android and iPhone apps for recreational fishers, including several apps that can provide information to management bodies (i.e., auto-report catch data to the relevant authorities on behalf of the fisher) (Gutowsky et al. 2013). As the role of apps has grown in recreational fisheries, scientists and managers have learnt to get the maximum benefit from electronic catch reporting.

1.1 Objectives

This review assesses options for streamlining and improving the current electronic reporting process for the Victorian Recreational Rock Lobster Tagging Program. Specifically, we:

5. Outline the current Victorian Recreational Rock Lobster Tagging Program App (VicRLTag App).
6. Assess app features that are available or being developed for recreational catch reports that could be integrated into a new version of the VicRLTag app. This includes discussion of a selection of other recreational catch reporting apps that inform management decision-making.
7. Identify and evaluate biases that may affect the data accuracy of electronic catch reporting programs and the potential influence of these biases on the VicRLTag App.
8. Present recommendations for consideration by the Victorian Fisheries Authority during the further development of the VicRLTag App in the 2020/21 season.

1.2 Methodology

This study consists of four major components:

5. An evaluation of the current VicRLTag app and recreational tagging program, including obtaining fisher feedback at the Recreational Rock Lobster Tagging Program Steering Committee provided at meetings between August 2020 and July 2021 that guided the development of the project.
6. A review of recreational catch reporting apps including the features and reporting fields. This encompassed interviews with leaders of a selection of catch reporting programs that provide insights into lessons learnt and cost-benefits of different app features and implementation strategies.
7. Three fisher surveys were conducted:
    a. An initial survey to obtain feedback from recreational fishers on the Recreational Rock Lobster Tagging Program, demographic information on the participants in the fishery and the fishing behaviour of survey participants.
    b. A diary survey to obtain additional catch, effort and catch rate information which was conducted in parallel to the start of the 2020/21 season.
    c. A wrap-up survey that tested the appeal of potential app revisions on survey participants and obtained feedback on possible changes to the reporting program.
8. An assessment of biases that can influence catch reporting apps.

The information collected from the above studies were used to develop recommendations for the revision of the VicRLTag app and the Victorian Recreational Rock Lobster Reporting Program more broadly.

2. Current Catch Reporting App (VicRLTag)

Since the commencement of the Victorian Recreational Rock Lobster Tagging Program in July 2017, recreational rock lobster fishers have been required to tag and report catch to the Victorian Fisheries Authority (VFA) for reliable estimates of recreationally caught rock lobster in Victorian waters. Each season, all recreational fishers harvesting or attempting to harvest rock lobster are required to register in the Victorian Recreational Rock Lobster Tagging Program, obtain tags prior to fishing and report the fate of the tags (as used, not used etc.) by the end of the season. The Victorian recreational rock lobster app (VicRLTag), which is compatible with iPhone, iPad and Android devices as well as accessible through a web interface, was developed for electronic submission of these mandatory catch reports (Figure 1).

The Victorian Recreational Rock Lobster Tagging Program currently involves a two-stage process, first fishers are required to physically tag the catch, and then report of the fate of all tags issued to them (used not used etc). Where a tag is reported used, fishers are asked questions on the catch, such as lobster length and the management region in which the lobster was caught. The program has a low number of active participants (24%) who report catch compared to the overall number of participants registered in the program (5586) in 2018/19 (VFA 2020) implying (under the assumption of high compliance) relatively low active participation in the rock lobster fishery relative to those intending to fish each season. The fate of a substantial number of the tags issued to registered fishers each year remain unknown, that is the number of tags that are unreported (e.g., 34.5% in 2018/19). A recreational fishing licence is required (unless exempt) to fish for rock lobster in Victorian waters, however, often licence numbers and the VFA licence database are not linked to a fisher's VicRLTag account. Consequently, reported catch is only associated to a user by the registered email address, which can change over time and make it difficult to identify individual fishers and accounts or obtain information on the overall fishing behaviour of account holders such as participation rates and new entrants into the fishery.

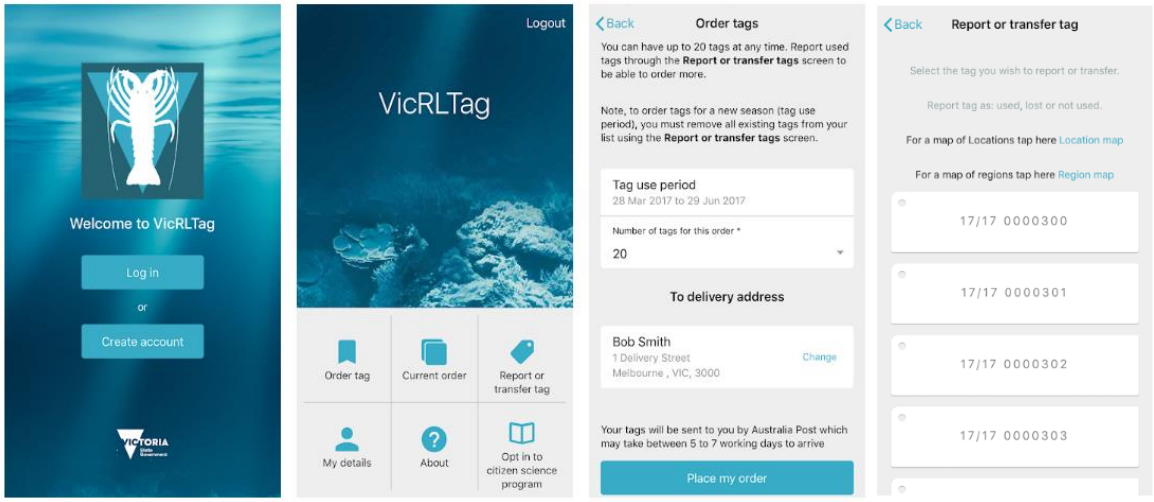


Figure 1 *Screenshots of the VicRLTag app.*

2.1 Current Data Collected

Demographic data collected consists of a user's name, email address, delivery address, date of birth, and phone number. In some cases, a Victorian recreational licence number is also voluntarily provided by the fisher. General catch data collected consists of date fished, date reported, tag number, length, zone fished, and region fished. The status of any tags not used by fishers is reported at the end of the season (i.e., tags are reported as unused or lost and where no report is provided for a tag the fate is

unknown). A flag is provided to indicate if the fisher has registered to opt-in to the voluntary the citizen science program. Data collected as part of the voluntary citizen science program includes weight, sex, species, fishing method and fishing time taken (effort). The citizen science component allows fishers to voluntarily report additional biological and operational information that is also important for managing the fishery, but without deterring catch reporting by imposing excessive reporting requirements on fishers unwilling to report the additional information.

One of the limitations of the data currently collected is that it is difficult to calculate a meaningful catch rate (an index of abundance) due to three issues. First, there is no measure of unsuccessful fishing trips (VFA 2020). That is, the number of trips where rock lobster fishing occurred, no catch was obtained (a true zero catch), and consequently, no catch report was submitted. Second, the fishing method and time taken to obtain catch (the effort measure that is required to calculate catch rate) are only reported by citizen scientists, which are a small proportion of participants, and not all citizen scientists report all this additional information with each fishing trip. Last, lobster weights are often not reported even by citizen scientists and, due to the large range of values, likely to be based on estimates rather than measurements. Lobster weights are also inconsistently reported as either grams or kilograms. This affects total catch estimates (e.g., percentage of the total allowable commercial catch (TACC) taken) as well as catch rate estimates. In the current dataset some inaccurately reported data is detectable, such as lobster weights reported over 10kg that are unrealistic.

2.2 Current App Features

The current features available to users in the VicRLTag app are:

- Map of location/region fished – users have the option to input a location or view a map of the regions to select from along the Victorian coast.
- Account details – users can update their personal details and demographic information including home and delivery addresses, date of birth, licence number, email, and name.
- Order tags – users can order tags for the current season they are registered to participate in. For the first 3 years of the program, have a total of 20 unreported tags available in their account at any time. In the 2020/21 season the number of tags a participant could have available in their account was reduced to 10 to reduce plastic waste from the program as most fishers used <10 tags in the first 2 years of the program. Each tag allocated to a fisher's account

has a unique code number that needs to be acquitted in catch reports or tag transfers by the end of the season to be eligible to participate in future seasons.

- Report tag – users report tag status as used, unused or lost. The reported tags are removed from the number of available tags, thereby allowing users to order additional tags to replace the reported tag/s up to the tag limit (10 tags since 2020/21 season). All tags in a fisher's account are required to be reported as used, unused, or lost to participate in future seasons.
- Transfer tag – users can transfer tags to the accounts of other registered fishers.
- Citizen science program opt-in/out – users can volunteer to join the citizen science program and provide additional information on catch, such as fishing method, fishing time, sex, and weight.
- Multi-platform capability – individual accounts can be accessed on multiple devices (i.e., iPhone, iPad, and Android).

2.3 Database Configuration

The current data storage arrangements are that account holder details are held separate to the database holding the reported tags (catch reports). Accessing the reported tag data requires a third-party provider who maintains the database to provide a read-out of the database to VFA. This extraction process has taken up to a week, thereby delaying analyses and delivery of reports which are often to a tight timeline. Additionally, in the current database structure VFA have limited direct access to the data and administrative functionality, such as creating csv files and conducting basic data analysis.

2.4 GoFishVic App

In addition to the VicRLTag app the VFA also operate the GoFishVic app, a voluntary electronic catch logbook for all recreationally caught fish species in Victoria, which has more built-in functionality for fishers than VicRLTag, such as weather reports, personal catch statistics, and set-and-forget automatic (hail in/hail out) trip reporting (Figure 2). There is the potential that the electronic catch reporting of recreationally caught Victorian rock lobster will be integrated into the GoFishVic app, effectively phasing out the VicRLTag app, to access the additional built-in features and streamline the reported of all recreationally caught species into one electronic platform. Consequently, mandatory rock lobster catches would be reported in the voluntary reporting app GoFishVic rather than in a stand-alone app.

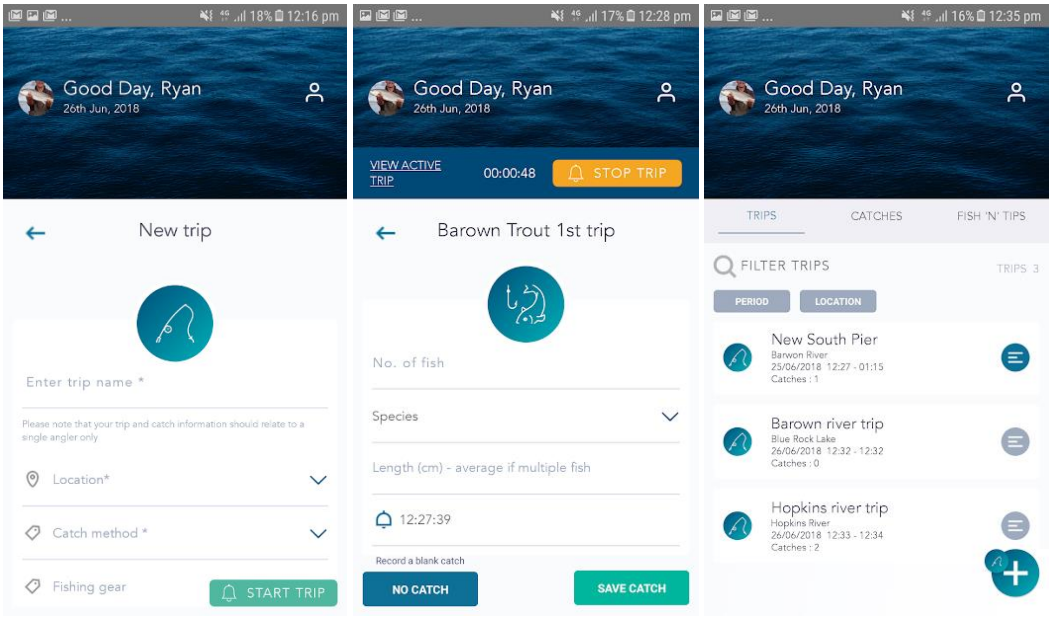


Figure 2 *Screenshots of the GoFishVic app.*

3. Potential App Features

There are many apps available for recreational fishers to voluntarily record catch or report catch to management as required. The present review of the VicRLTag app presents an opportunity to survey features available in recreational fishing apps more generally, with a view to potentially integrating those deemed useful into VicRLTag. In this section, we identify various features and data variables that are available or used in other recreational fishing apps that could be added to the catch reporting process in the Victorian rock lobster tagging program. The benefits, limitations, and potential implementation (utility) of the features used in recreational catch reporting apps that could be added to the VicRLTag app are presented (Table 1). App features are divided into those that provide direct implications for estimating catch and those that are an incentive aimed at improving compliance, increasing data accuracy, and maintaining participation rates.

Table 1 *The possible features that could be considered for implementation in VicRLTag that are aimed at addressing direct management needs (blue) and the features that improve user experience, thereby incentivising improved data quality (green). For each feature the potential benefits, limitations, and integration into VicRLTag are outlined.*

New Features	Description	Benefits	Limitations	Utility in VicRLTag
Digital Tags	A digital tag (unique identifier) is automatically generated and allocated to a catch report, possibly with a photo.	• Reduce plastic waste. • No manufacturing costs • Users do not have to wait for delivery of physical tags. • Potential reduction in misreported tag numbers.	• Contact address not verified. • Possible compliance issues • Necessity to take phone to place of fishing (unless a pre-trip log is developed, or reporting regulations relaxed to allow users to report on a desktop after returning).	• Streamline the tagging and reporting of catch into single- step process. • Unique tags either electronically allocated to an account or autogenerated for a report. • Photo linked to a report could provide additional information to query if outliers in the report need verification. • Accountability and compliance framework would need to be developed.
Geolocation	Auto-fill fields from the phone's GPS location.	• Auto-fill location. • Provide high resolution latitude and longitude measurements. • Reduce misreported location.	• Some phones will not be compatible or contain a GPS. • Users will need to grant additional permission to the app.	• Agreement or terms of use will need to be provided to fishers on tracking and privacy. • Initially, implemented in parallel with the current

		• Reduce time for fishers reporting location.	• Giving specific GPS location access to VFA may cause trust concerns unless information is scaled to a coarser area. • Requires location over-ride for delayed or forgotten reports.	manual spatial reporting, but encourage users to increasingly adopt geolocation as more smart phones are used by Victorian recreational rock lobster fishers. • The latitude and longitude co-ordinates could auto-fill the map-code region and zone fished reporting fields.
Offline Reporting	App saves a completed report until offline phone or device is connected to the internet.	• Reporting available even when out of mobile reception. • Fishers can report catch without waiting for mobile coverage.	• Potential to drain battery of device.	• The majority of VicRLTag users (55% in 2018/19) report tags the same day that catch was taken. This percentage had decreased 5% from 2017/18. Offline reporting can assist fishers to report the same day even without reception. • Same day reporting increases the accuracy of the data compared with recall/memory-based reporting.

Trip Log/ pre-registering an intention to fish	Fishers pre-register an intention to fish for RL on a day.	• Could consider relaxing the requirement for tagging of catch and having the device on-hand if an intention to fish is lodged. • Opt-out if situation changes and fishing did not occur. • Report true zero catch if fishing trip was unsuccessful.	• Additional impost on the fisher. • Need to consider how to deal with opportunistic catches (i.e., not on a planned fishing trip).	• Current Victorian regulations require lobsters to be tagged within 50m of shore. Pre-registering a trip (intention to fish) could allow the relaxation of this regulation to allow fishers to report catch until returning to a desktop or phone. • An opt-out should be built-in to cancel a trip (intention to fish) if plans changed and no fishing occurred. • Zero catch (unsuccessful fishing trip) could also be reported. Thereby improving catch rate estimates from VicRLTag data.
Automatically Time/Date - stamped	Auto-fill time and date from device.	• Reduce time taken for a fisher to report tags.	• Fishers could date/timestamp when reporting rather than when catch occurs. • Should be editable to backdate for reports that	• VicRLTag had a decrease of 5% between 2017/18 and 2018/19 in the number of tags reported the same day as the catch occurred.

			are delayed or correct errors by contacting an administrator who can override the data.	• Automatic time and date stamps from a device are incentive for fishers to report catch when returning to boat or shore by simplifying the reporting process (automatically filling out fields).
Photo upload with geolocation	Autofill reporting values from uploaded photo (e.g., location).	• Can be used with personal statistics or social media. • Autofill reporting fields to make reporting faster. • Verification method for data entered.	• There will be an unknown amount of uncertainty depending on the device capabilities and specifications used by the fisher.	• VicRLTag could include photo documentation that is linked to other features (e.g., geolocation) or used as a back-up verification of the catch report.
Rock Lobster Information	Provide information on the species' biology when catch is reported.	• Increased information to fishers. • Data-sharing between management – fishers.	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• VicRLTag could support incentives to maintain participation in the program and increase accuracy of data reported. • This could be in the form of an 'interesting fact' or trivia question loaded with each reported tag or a page dedicated to interesting biological facts on rock lobster.

Management Information (current rules and regulations)	Provide up-to-date information on regulations (catch limits etc.) from the VFA webpage on rules.	• If geolocation is enabled, can notify fisher when in a marine reserves or entering/exiting areas with different management regulations.	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• VicRLTag could support incentives to maintain participation in the program and increase accuracy of data reported. • This information, which is already on the VFA website and in the recreational fishing guide, could promote compliance as the regulations are readily available to fishers.
Personal Log (Diary) of Reported Catch/Effort	App keeps a record of a fishers' personal catch reports.	• Fisher can track locations with high success (catch rate) and track experience. • Feature in commercially available apps. • Promote accurate reporting to keep track of personal record with increasing experience.	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• VicRLTag could support incentives to maintain participation in the program and increase accuracy of data reported. • Some apps allow logs to be edited, however, in the interest of encouraging data quality, accurate reporting in the first instance should be encouraged. • A personal log could be an additional incentive provided to those who opt-in to the citizen

				scientist program and report additional information.
A digital wallet for storing licences and fishing documents	Store digital copies of fishing documents within the app for easy access.	• Capability to link user to additional information such as licences, other targeted species caught.	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• Some recreational fishers have voluntarily provided their recreational fishing licences to the VicRLTag accounts. A digital wallet could link all licences to the account. Alternatively, it could be compulsory to provide licence numbers in an account profile.
Save fishing locations on map	Fishers can save pinpoints of fishing locations. The potential to link to social media and share locations.	• Location can be input into catch report from saved location pin. • Fishers can track their preferred locations to fish.	• Locations may be shared among fishers and target fishing intensity in specific locations. • Fishers may have concerns about providing fine-scale data.	• VicRLTag already provides a map for users to choose and report a location fished. This could be expanded upon to allow saveable pinpoint locations. • Locations/waypoints may be set by GPS locations to ensure spatial accuracy. • Restricted use of points as reporting locations as nearest point selected may not be as accurate as geolocation.

Comparison of personal log/ statistics	Keeps a record of the fisher's personal statistics (e.g., catch rate, catch, effort, most successful locations/times/months).	• Fisher can track fisher preferences. • Feature in commercially available apps. • Participants can track catch rate with experience.	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• VicRLTag could support incentives to maintain participation in the program and increase accuracy of data reported. • Could be an exclusive incentive feature for participants who opt-in to the citizen scientist program.
Multi-platform compatibility	Apps that can be accessed on multiple devices (e.g., different phones, tablets, desk-tops).	• Increase accessibility of fishers to electronic reporting methods.	• Multiple app versions are required for each platform.	• VicRLTag is already available for iPad, iPhone and Android devices and has a web-portal. Ensuring the syncing of devices and reporting platforms (i.e., submitted catch reports can be accessed from webpage and devices) would be beneficial.
Photo upload (optional)	Incentive. Option for fishers to accompany the catch report with a picture.	• Additional data acquisition • Digital tag allocated to a rock lobster in a photo.	• Only useful if photos are checked and data mined: i.e., species identification checked. • Saving photos will increase the size of the database required to store catch reports.	• There are limited enhancements to the data already obtained by VicRLTag by including photo documentation with catch reports unless the photos are linked to other features or used as a

				back-up verification of the catch report.
Solar/Lunar/Tide /Weather Guides	Allow fishers to access and save information on environmental conditions.	• Feature in commercially available apps. • Allows fishers to track favourable conditions with catch rate. • Can be linked to smart watches	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• VicRLTag could support incentives to maintain participation in the program and increase accuracy of data reported. • This feature promotes the use of VicRLTag
Route/trip tracking and planning	Option to use devices GPS to track a fishing trip or maps pre-plan trip locations	• Feature in commercially available apps. • Fisher can have a record of previous trip locations and pre-emptively plan trips.	• No real catch reporting benefit except to encourage reporting and participation (boosting compliance and data availability).	• Agreement or terms of use will need to be provided to fishers on tracking and privacy. • Potential to be built-in to existing VicRLTag maps.
Weight estimates from phone	A developmental stage app feature that aims to calculate weight from mass in picture or on camera/screen.	• Potential to improve the number of weights reported and accuracy of reports	• Feature not compatible with all phones. • Feature in development with high uncertainty and inaccuracy in obtaining an accurate weight from carapace length in photo. • Difficult to set up/calibrate that would require high-end devices and technological knowledge from users.	• As this technology is only in the developmental stage and requires accurate length/mass measurements, which are also in a developmental stage, the data is considered to be more accurate through manual measurements. Estimating weight from length-frequency estimates or providing scales at key

			• Unlikely to be of sufficient accuracy to be scientifically useful unless estimated from length-weight calculations based on the reported length.	port locations may be more successful in obtaining accurate estimates of weight. • Current weight measurements recorded in VicRecTag are highly variable and possibly estimated by fishers. • Limited accessibility (fishers who have compatible phones for the feature) could reduce the number of weights reported.
Ruler for carapace length	Augmented reality. A ruler feature that can measure carapace length from the device camera (if available).	• Measure carapace length without calliper. • Potentially faster method than manually measuring carapace length. • In theory, consistency between fishers.	• Technology not compatible with some smartphones for example low resolution camera phones that may fail to detect the middle notch of the antennae from which to measure carapace length. • Measurement accuracy lower than with traditional methods e.g., measuring	• Although a good concept in theory, given the accuracy of data obtained it may have little scientific value and it would be better if length was measured and reported manually. • The length data obtained currently through the VicRLTag is good quality. • The limited access for all users to the technology

			device/callipers in mm units. • Measurements likely to be too inaccurate for scientific purposes. • Measurements cannot be relied upon for a fisher to determine if a lobster is legal sized. • Extremely high implementation cost to develop and test a feature with adequate accuracy to use in difficult conditions such as on a boat. • High variability in measurements between phones depending on the device specifications.	(requiring a smart phone with complementary capabilities) could limit reporting length through this function.
Photo upload for algorithms to determine lobster features (e.g., length, gender)	A ruler feature that can measure carapace length from the devices a photo using augmented reality technology.	• Measure carapace length without calliper. • Potentially faster method than manually measuring carapace length. • In theory, consistency between fishers.	• Technology not compatible with some smartphones. • Measurement accuracy lower than with traditional methods. • High variability in measurements between phones.	• Although a good concept in theory, the calculated lengths may have little scientific value and it would be better if carapace length is measured and reported manually.

			• Measurements likely to be too inaccurate for scientific purposes. • Measurements cannot be relied upon for a fisher to determine if a lobster is legal sized.	• VicRLTag could include photo documentation to support the manually reported information. • The use of augmented reality could be considered in the future when the technology is more accurate to report carapace length and easily accessible to recreational fishers.
Export or download information	Fishers can export or download their previous (personal) trip information info a spreadsheet.	• Fishers can download their personal catch information as an incentive for using the app and maintaining participation in the program.	• Only personal records should be accessible due to confidentiality of data.	• Fisher access to personal VicRLTag records could incentivise participation by facilitating greater user interaction with the data they provide and transparency.

3.1 Potential App Variables

Here, we outline additional data that could be collected in the VicRLTag App (Table 2). The possible new data variables include further demographic information and expanded catch reporting factors. While it is important to gather as much relevant information as possible, participant burden at complex and time-consuming reporting and data redundancy are also important to consider. Currently, only 11.6% of participants have opted into the citizen science program to voluntarily provide additional information on catch, however, just 50% of these citizen scientists have reported used tags, that is have reported fishing (VFA 2020). Therefore, there may be opportunities to incentivise contributions to the citizen science program with the aim of increasing participation and expanding the questions asked to users to provide a better understanding of the fishery, such as reporting zero catch (unsuccessful fishing trips) or the target species.

Table 2 *Additional data collected in other catch apps that could be added to VicRLTag.*

Variable	Description	Utility in VicRLTag
Fisher gender	Demographic data.	There is currently no ability to analyse gender demographics in VicRLTag.
Fisher nationality	Demographic data.	Registered rock lobster fishers in Victoria since 2017/18 have been primarily Victorian residents with <1% inter-state residents. Ethnicity is not currently measured in VicRLTag.
Fishers' fishing experience	Demographic data.	The skill of a fisher is important context that can help interpret catch reporting data such as participant retention rates and catch success rates. Fishers could be asked to indicate the number of years they have been fishing for rock lobster in Victoria. Information could be entered once off in the account profile and automatically updated each year.
Fisher preferences	Demographic data.	Users can save their preferred fishing locations, targeted species, fishing methods etc. This could provide background information to managers on fishing behaviour and desired fishing attributes.
Fisher memberships of fishing/dive clubs	Demographic data.	Memberships to fishing clubs can be combined with years of experience to profile fisher engagement. Information could be entered once off in the account profile and edited by the user as required.
Trip duration	The length of time spent on a fishing trip from starting a trip	The length of time spent on all fishing activities undertaken during a fishing trip could be combined with a list of fishing activities undertaken. The information could be used to

	(hailing in) to ending a trip (hailing out).	distribute catch and effort among different recreational fisheries.
Fishing start and end time	The time spent actively fishing during a fishing trip.	Start and end times are important in rock lobster fisheries with a substantial hoop netting or trapping component where the soak time and time of the day can influence the effort and catch rate. The time of day fished for rock lobster is less important than the time spent actively fishing (effort) in a primarily dive-based fishery. Currently, the citizen scientists can report fishing time in the VicRLTag app in hours/minutes which is more informative than start and end times.
Target species	Fishing trips where rock lobster fishers target multiple species or opportunistically harvest additional species.	Fishers can list the species they were targeting, such as abalone, if not exclusively fishing for rock lobster. The benefit of reporting trips where multiple species are targeted is that effort (time spent actively fishing) can be adjusted to improve accuracy in catch rate estimates.
Fishing platform	Boat or shore-based fishing preferences.	Fishing platform in this case refers to shore- or boat-based fishing.
Fishing depth	Depth from which the catch was obtained.	The depth that rock lobster is harvested from can be used to indicate the fishing intensity spatially.
Fishing party	The number of fishers in the fishing party.	The size of the fishing party can be used to indicate catch in voluntary programs. However, as all members of a party who caught rock lobster in Victoria are currently required to report their catch (rather than a skipper on behalf of the boat), this has limited benefit. Where knowing the fishing party would be beneficial is in programs where there is no measure of a zero catch, such as in the current version on VicRLTag. However, if mechanisms are adopted for users to report zero catch for a fishing trip, then the size of the fishing party is only providing demographic data.
Catch reporting by proxy	Option to report catch for others in fishing party.	As it is a requirement that all recreational fishers hold a VicRLTag account and report tags used this should not have a major influence on the data obtained. However, it may be useful in the small number of cases where all members of a fishing party do not have access to a phone to submit a report.

Unsuccessful fishing trip	Fishers report if no catch was made (true zero catch) on a fishing trip.	This is an important variable for calculating catch rate. The variable could be integrated into VicRLTag through features listed in Table 1 such as logging a trip and reporting no catch if zero rock lobster were harvested.
Species and number caught	Total catch (species and numbers) harvested during a fishing trip.	The exact species other than rock lobster and number caught are reported in GoFishVic app. To reduce reporting fatigue doubling up on this information may not be beneficial compared with forming links between user accounts and fishers across both apps. A targeted species report would also achieve similar information at a courser scale.
Spawning status	Rock lobster in berry observed during fishing trip.	Victorian rock lobsters are protected when in berry (carrying eggs). Therefore, the caught rock lobster should not be berried and this variable would be generally uninformative. This variable could be applied in a sighted while fishing context, however, this is outside the objectives of VicRLTag.
Frequently asked questions (FAQ) page	General questions and information on how data will be used.	A section that can clarify information on the purpose of the citizen science program, the rock lobster tagging program, data acquisition and the VicRLTag app. Information for much of this could be taken directly from the VFA website. A definition of each variable could be provided and the units of measure.
Recreational abundance index	A general abundance measure of the number of lobsters observed during a fishing trip and not harvested.	A recreational measure of the abundance of undersized lobster observed during fishing trips has been requested from Victorian stakeholders to collate anecdotal observations. Establishing a meaningful index with consistent baselines will be difficult. Data accuracy is likely to be more robust with abundance calculated through traditional methods in fishery assessments.

3.2 Social Network Integration

Optional social network integration can assist in incorporating socio-economic factors into app reporting and provide a platform that is competitive with commercially developed apps for recreational fishers (Papenfuss et al. 2015). In essence, social network integration provides incentives (like those outlined in Table 1) for fishers to recruit into and retain app usage within and between seasons. Although social interactions may not directly align with management objectives, information-sharing networks are important in shaping fisher satisfaction, success, and behaviour (Turner et al.

2014). Integrating incentives, such as social networking capabilities, progresses VicRLTag beyond a one-way reporting tool to a two-directional communication platform and encourages on-going fisher participation and engagement in the program.

3.3 Smart Watches

Smart watches are an emerging technology with increasing popularity and utility with fishers (Hartill and Thompson 2016). The size and reduced computational capacity are currently limitations to the widespread usage of smart watches in recreational fishing, however, syncing between smart watches and other reporting platforms (e.g., phone or desktop account) could be useful for more complete catch reporting. Smart watches can be used to measure fishing time, location, and depth fished, and to load incentive features of the reporting app. This is a developing technology that may be useful in the future, and if smart watches become common amongst Victorian recreational fishers in the future, then expansion of the VicRLTag app to be compatible could be considered.

Worldwide, more than 3.7 million catches have been voluntarily reported by recreational fishers on the FishBrain app, a commercially developed app with little evidence of this information being used to inform management decision-making, which highlights the willingness of recreational fishers to complete catch reports and provide information electronically (Bradley et al. 2019). FishBrain tracks a fisher's methods and catch rate over time with the aim of the fisher learning from previous personal experience, therefore, providing an additional incentive for fishers to use the app (Fujita et al. 2018). While this app is accessible on multiple platforms, such as mobiles and tablets, it has also been adapted for reporting catch, catch location and fishing time using smart watches (https://fishbrain.com/gear/categories/202/smart-watches). An example of the smart watch app can be found: https://wsd.casio.com/intl/en/app/featured/fishing/).

4. Implementation of Catch reporting Apps

Catch reporting programs that use electronic data collection from apps are of emerging interest to inform management decision-making with numerous implementational challenges and opportunities having arisen from the new technology. Here we discuss the benefits and limitations of

implementation strategies for a selection of catch reporting apps available to fishers that inform management decision-making. The lessons learnt and global perspectives from voluntary reporting apps iSnapper (Texas, USA), MyFishCount (South Atlantic Fishery Management Council, USA), and Fangstjournalen (Denmark), as well as mandatory reporting apps Snapper Check (Alabama, USA) and Tails 'n' Scales (Mississippi, USA) can provide valuable information to guide the revision of the VicRLTag app. The information presented is from both published literature and interviews with program developers and leaders. The details of the program developers and leaders we contacted and list of additional example apps for recreational fishers can be found in the Appendix. A detailed outline of our discussions with each app is also provided in the appendix.

4.1 iSnapper (Texas, USA)

The iSnapper app was created in 2011/12 to track recreational catch and was tested with for-hire captains in the Gulf of Mexico before being expanded to include recreational fishers in 2015. When using iSnapper, geolocated co-ordinates, which can be edited later, are recorded and a trip log (hail - in to register an intention to fish and hail out to close a fishing trip) are created for each fishing day (Stunz et al. 2014). The electronic reporting in iSnapper can be conducted in both an app and an online portal. However, a review of platform usage revealed that the online portal was rarely used and, when accessed, its main function was to edit or review historic trips and access personal catch statistics (Stunz et al. 2014). Although the app was initially made for Apple iPhones, a version for Apple iPad was developed as it was the preferred device by participants. Low participation rates are a potential issue, which can add bias, limit data availability to upscale findings, and ultimately reduce the effectiveness of any catch rate measure, in the voluntary iSnapper program (Stunz et al. 2014).

4.2 MyFishCount (South Atlantic Fishery Management Council) and iAngler (Florida, USA)

MyFishCount app was developed for recreational fishers to voluntarily report snapper catch to management bodies (Fujita et al. 2018). Catch reporting consists of drop-down menus and check boxes to minimise input errors and user inputs are divided into three steps: trip registration, catch reporting, and trip closure (Collier et al. 2019). The program operates a smart phone app and a web-based portal for fishers to report catch, view historic catch reports and access aggregated data analyses.

iAngler is self-reporting app for recreational fishers in Florida. The program has recruited a panel of volunteer participants through word of mouth (Joirle et al. 2016). The retention rate of iAngler participants is 10% annually and, therefore, participation and demographics are highly variable (NOAA 2019). There was similarity between submitted iAngler trip reports and recapture surveys used to validate the data collected in the app (Joirle et al. 2016).

4.3 Snapper Check (Alabama, USA) and Tails 'n' Scales (Mississippi, USA)

Snapper check and Tails n' Scales are mandatory catch reporting programs in the USA with app-based electronic reporting. Snapper check and Tails n' Scales have a two-step reporting process: compulsory electronic reporting for all fishers and then upon returning to port there are shore-based surveys conducted as part of the Marine Recreational Information Program (MRIP) to verify the reported catch on the app (NOAA 2019). The two-step approach aims to increase the accuracy of data reported than with a self-reporting app alone. The two-stage approach does not require tags or photos nor a high level of compliance, however, the data obtained in the app requires adjustment (based on the surveys) to account for non-compliance.

4.4 Fangstjournalen (Denmark)

Fangstjournalen is a voluntary catch reporting program operating in Denmark. Fangstjournalen is unique in that it was designed by scientists who continue to operate the program and also focus on electronic catch reporting research. Although there is an increase in the use of recreational catch reporting apps, research by scientists involved in the Fangstjournalen app has found that electronic catch reporting fail to solve all the problems related to measuring catch and catch rate and should not be stand alone. Rather apps should be used in combination with traditional methods with the objective of achieving fisheries specific corrections to catch rate data. Data collected in Fangstjournalen has been used by Skov et al. (2020) to outline the limitations and development of catch reporting apps that promote data quality and utility and a European Commission (2020) report that compares catch reporting apps and discusses the best practice for developing electronic catch reporting programs.

4.5 Key Learnings and Global Perspectives

4.5.1 General Comments

The recreational fishing app programs reviewed here, with the exception of Fangstjournalen, were developed in response to various undesirable resource states, and their usage patterns reflect these states and associated management responses. Stressed fisheries with restricted open season days and limited data availability were the catalyst for recreational app reporting in the MyFishCount and Tails 'n' Scales programs, while iSnapper recorded an increase in app usage when open-season days were reduced. The objectives of voluntary programs such as MyFishCount and iSnapper is to obtain information and trend data on the fishery, while app reporting programs with a mandatory reporting framework, such as Snapper Check and Tails 'n' Scales aim to obtain reliable catch estimates. Due to limited open days (as low as 3 in Mississippi) the participants in the Tails 'n' Scales program were looking for a program to report catch and improve data, which resulted in high compliance rates, as trust in decision-making had eroded. Generally, recreational catch reporting programs including iSnapper and Tails 'n' Scales, experienced an increase in reporting rates when fishers saw value in providing the data, such as the data being used in decision-making to the benefit of fishers resulting in increased open season days or open seasons guided by near-real time catch estimates. Therefore, the willingness to report and acceptance of catch reporting has increased in most programs when the utility and benefit of providing the information is transparent to fishers.

When developing an electronic catch reporting program, start-up and on-going operational costs to operate should be quantified and planned for prior to commencement. While electronic catch reporting can be cheaper than traditional fisher surveys, substantial investment is required both at start-up and on an on-going basis if the program is to succeed. iSnapper had a ~$100 000 budget for start-up and ~$100 000 for on-going costs. Snapper Check had US federal funding of $10 000 in the first two years of the program for the development of the electronic components of the program. When developing a catch reporting app, MyFishCount developers recommend that the set-up and ongoing costs are established and measures of success or failure at specific timesteps (e.g., 1, 3, 5 years) are created.

The Mississippi Tails 'n' Scales program is considered by iSnapper and Snapper Check as the gold standard or ideal electronic catch reporting program except for the logistical support needed to implement into larger and more diverse fisheries. The benefits of the tails 'n' scales are that the hail in/hail out (trip) reporting can have boat enforcement as a trip has to be started. In Alabama

Snapper Check, compliance officers are unable to make inspections until a boat has reached land. This makes compliance more difficult and less successful, with the potential for "stand-offs" wherein fishers deliberately keep their boats in the water when they can see compliance officers waiting onshore. The difficulty in applying a similar Tails 'n' Scales system in in larger fisheries is the substantial administrative burden involved in implementation. Fisheries with more extensive coastlines, such as Texas, and diverse fishing demographics including a higher number of tourists and a shore-based fishing component, for example in Alabama, may have difficulty obtaining the operational capacity to implement a Tails 'n' Scales system.

Given the type and quantity of data collected in electronic catch reporting for recreational fisheries, having a plan for quality assurance and quality control (QA/QC) of data is important from the outset. Snapper Check program leaders recommend the employment of a full-time data analyst. Similarly, MyFishCount developers suggest recreational catch reporting programs use the specialties, such as data scientists and universities who have the skill and resources available, to regularly supply and quality control information to fishers. For quality control, Snapper Check and MyFishCount apps lock submitted catch reports and no editing controls are provide to fishers. Instead, changes to submitted catch reports must be requested by contacting the program administrators. However, catch records in iAngler can be edited for three months before being locked. During interviews with all the recreational catch reporting programs contacts, there was consensus that substantial on-going time allocations and resources are allocated to analysing and quality controlling the data, which should be complemented with well-designed validation methods, prior to communicating the data with fishers and informing management decision-making.

A cultural shift towards acceptance of recreational catch reporting has needed to be overcome in many fisheries for acceptance of catch reporting apps. Snapper Check is embedded within an Alabama State hunting app (Outdoor Alabama) to help normalise catch reporting. Traditional cultural practices have a role in uptake and persistence with reporting programs, for example, in Denmark hunters have been required to report catches for generations and reporting into catches is routine. Therefore, catch reporting in recreational fisheries will normalise and become standard practice in cultural traditions over time.

4.5.2 App Usage

Trip-based reporting can be completed by fishers up to one day after the event in iSnapper. In MyFishCount, users receive a notification to close an incomplete trip report and the record made invalid if the report is not completed within a certain timeframe. Snapper Check users must report catch prior to landing with compliance checks enforceable at the place of landing. In contrast, Tails 'n' Scales requires fishers to register a trip prior to departing, which is allocated a unique identifier code that can be used for compliance checks at sea or on landing. However, Fangjournalen allow fishers to report at any time and report historic catches to build up personal catch statistics and increase participation in the voluntary reporting app. Trips where zero catch was harvested are reported in Fangstjournalen to improve estimates on the personal catch statistics of anglers.

The developers of MyFishCount developed a comprehensive list of variables for fishers to report against, which in retrospect would have been more beneficial to focus on key variables. Tails 'n' Scales developers consider 5-9 questions the maximum anglers can be asked before engagement in the app and reporting accuracy is reduced. Rapid reporting time is a key marketing point for gaining fisher support by promoting ease of reporting and limited time commitment. For example, iSnapper promote <5 minutes for fishers to submit a catch report and Snapper Check <1 minute to discourage user fatigue and non-reporting. An easy to use and focused reporting format, which prioritises the information required to achieve the core objectives, is crucial to the foundation to a successful electronic catch reporting program that encourages recreational fisher engagement.

While most apps that are designed to inform management decision-making focus on the reporting of one target species, such as VicRLTag in the current structure of the program, there is functionality to report multiple target species in some programs. The functionality to submit a catch report for multiple target species on a fishing trip was available in iSnapper, but only snapper catches were reported by users. Snapper Check, while a mandatory catch reporting app for snapper, allowed users to voluntarily submit catch reports for other species. Scientists were unhappy with the quantity of data being obtained (~30-40 trips logged a year) for 2 species with voluntary reporting in Snapper Check, which was insufficient for effective quota management and resulted in shorter open seasons, and, consequently, these 2 species will have mandatory catch reporting from 2021. As the MyFishCount and iSnapper developers discovered, obtaining the raw amount of data for a catch reporting program to be successful and achieve its objective is a constant challenge for voluntary catch

reporting programs that lack the support of a mandatory framework with adequate compliance regulations.

Multi-platform reporting (iSnapper). Web-based portal and app reporting in MyFishCount that has one directional syncing (app to website), while Snapper Check has two-directional syncing between the website and app. Fangstjournalen developers recommend two-directional syncing between the app and website where the technological infrastructure can support it rather than stand-alone platforms that have been traditionally created. Snapper Check initially allowed fishers to report via app, paper-based log that was places in a box at selected sites with a carbon copy for fishers and website portal. However, in 2021 the paper-based reporting will be phased on of the Snapper Check program as it was only used by 8% of anglers and usually only when compliance officers were at the port. Fishers reporting into the Tails 'n' Scales only have the option to report via app or a call centre, however, 90-95% of fishers report using the app. In contrast, participants of Fangstjournalen can report catch either by website portal or in the app with most fishers reporting via the website, which is reflective of the demographics of the fishery (older, experienced anglers). An understanding of the demographics of participants in the fishery and their motivations for participating can, in the first instance, provide information on the most beneficial reporting platforms to invest in and incentives to include in the app until metrics data becomes available.

Incentives have been used extensively to encourage participants to report and increase app usage. iSnapper, MyFishCount, Fangstjournalen, and Tails 'n' Scales allow users to access personal log or records of catch as an incentive to report. Snapper Check incentives also include regulation notifications, weather information and licencing renewal and document storage. Users of Fangstjournalen app can also receive regulatory notifications if a trip is logged and the user has allowed Global Positioning System (GPS) tracking. In addition, Fangstjournalen users can conduct basic analysis of the whole dataset (raw and uncleaned) through filter functions. However, many recreational catch programs have privacy restrictions that would limit the access fishers have to the raw dataset. Give-aways or prize draws from sponsors as incentive for participants who reported trips were also used in iSnapper and MyFishCount. Offline reporting is available in Snapper Check, which provides easy reporting for fishers in remote locations and promotes increased compliance rates, while the offline reports are accepted by compliance officers. Notably, a trophies or awards feature was developed for iSnapper, but not used by fishers. Substantial resources can be invested in app features that have limited user uptake or success in encouraging increased reporting rates or

participant retention. The design of a recreational catch reporting app should focus on the main objective, that is to report catch and establish a high level of compliance.

4.5.3 Compliance and Non-reporting

Obtaining a high reporting rate is a constant challenge for voluntary apps that lack mandatory process with compliance regulations and the establishment of a well-developed compliance framework is desirable for MyFishCount and iSnapper apps. The reporting rate is estimated to be 12-2% (depending on the year) for the iSnapper app. While it is estimated ~5% of fishers report into Fangstjournalen app. Fangstjournalen reporting program initially experienced high uptake rates which declined over time before stabilising at ~1500 new participants each year.

The purpose of mandatory catch reporting programs is to obtain a high rate of compliance, in this case submitted catch reports, that provide the quantity and quality of information for management decision-making. Compliance rates in the Snapper Check program are estimated at 25-30%, which is reflective of the challenges in implementing mandatory catch reporting programs with education, communication and incentivisation that encourages compliance, and a consequence of the complex and diverse fishery in Alabama. Conversely, compliance rates in the Tails 'n' Scales program over the past 2 years is estimated to be 95%. The Tails 'n' Scales program operates in a smaller fishery and coastline area, relative to Snapper Check and iSnapper, with limited shore-based access points and a small number of ports. Therefore, compliance regulations, incentives and communication on Tails 'n' Scales can be targeted and, consequently, result in higher compliance rates.

One of the largest deterrents to implementing new or more restrictive regulations in mandatory reporting programs is backlash and deliberate non-compliance by recreational fishers. Phasing-in of regulations softly with a focus on education occurred in the first year of Snapper Check prior to enforcement coming into effect. Likewise, Tails 'n' Scales, which has the highest compliance rate and tightest mandatory catch reporting regulations that require pre-trip registration (hail in) and catch reports submitted prior to landing, had a period of enforcement focused on education before fines were issued.

4.5.4 Validation

Two-step mark/recapture surveys are used to validate the data reported electronically. The method includes 1.) the reporting of catch data by fishers (mark), and 2.) an independent dockside survey of catch (recapture). Comparative studies, such as dockside creel and traditional logbook or recall surveys are most commonly used to collect the recapture data (Venturelli et al. 2016). Except for MyFishCount and VicRLTag, the recreational catch reporting programs discussed in this section all validate the data collected using mark/recapture surveys. The MyFishCount program plan to implement data validation in the future (Collier et al. 2019). Creel survey comparisons are used in the iSnapper and Fangstjournalen programs to validate the electronic data collected and estimate non-reporting rates. Cross comparison of catch between an independent creel survey and the iSnapper app detected no significant differences in the reporting methods (NOAA 2019). Snapper Check has 18-20 full time staff that conduct dockside mark/recapture surveys during the season that are used to collect complementary information that can be used to validate app data and estimate biases. Further, cameras at docks are used to estimate the number of trips (effort) and anglers. The Tails 'n' Scales program conducts dock-side surveys by biologists that assess the accuracy of catch reports and provide a misreporting/non-compliance estimate for correcting the data.

4.5.5 App Development

Technical problems that result in slow apps or difficulty in using the app by fishers can adversely impact on the uptake and retention of participants. The extensive testing and debugging of an app prior to it becoming publicly available is recommended by the iSnapper program. While Frangstjournalen developers recommend focus groups are held for fishers to experience the app and provide development feedback to better cater to the needs of the target audience. Automatic updating of the app as new versions and patches are released occurs in Snapper Check, which encourages ease of use by automatically addressing bugs and technical issues and discourages non-reporting due to technical problems or inconsistent features/versions.

Metrics on app usage, such as features used and unsubmitted reports, were collected in iSnapper and Snapper Check, but not analysed. Collecting app metrics could inform and guide future developments, such as the phasing-out of under-utilised reporting methods (e.g., web portal) and investment in resources fishers use (e.g., the app for reporting). In addition, collection of app metrics can assist researchers and developers to identify the pages in the app that fishers stop reporting or have difficulty with.

Although there are many features that can be integrated into recreational catch reporting apps, the recreational catch reporting programs we contacted agreed that a basic app design and easy to use format are essential to engaging with the target audience. iSnapper program developers recommend recreational catch reporting app developers be aware and remain focused on the specific audience and purpose of the app. Computer programmers are familiar with the needs of a particular audience, gamers, rather than the requirements of recreational fishers. With the flash app features available today it is easy to gamify recreational catch reporting resulting in distractions and under-utilised features at the cost of the core objectives of the program. MyFishCount app developers recommend the app be as basic as possible with priority given to core information which can be complemented with additional information. Generally, all the recreational catch reporting programs contacted in this section agreed that a simple app and reporting program design that applies the techniques proven to be successful, that is it not to reinvent the wheel.

4.5.6 Communication

App uptake and acceptance by recreational fishers will be enhanced if advocates from the recreational fishery are used to advocate and promote the program and help to educate fishers in its use. Continued marketing to recruit and incentivise participants was required in MyFishCount with a graduate student currently engaged in undertaking an assessment of the success of outreach strategies. Feedback to anglers in the Tails 'n' Scales program is provided in an annual report and public presentation. The Fangstjournalen program has a weekly newsfeed that posts questions and data trends for fishers to discuss and provide feedback on as a method of increasing fisher engagement and participation. MyFishCount has automatically created reports (weekly or monthly) for anglers.

Some app programs (e.g., iSnapper) have used extensive promotion campaign including local fishing forums, magazines, advertisements, mail-outs and appearances on radio programs. MyFishCount detected increased participation rates when engagement activities were being undertaken such as dock-side information and presenting at fishing club meetings. Snapper Check utilised all possible media outlets to promote the program, but in person meetings and direct communication with the program leaders have been most successful at encouraging compliance and building trust-based relationships with fishers. The app platform creates the opportunity for increased communication between fishers and program leaders. For example, iSnapper included a voluntary social and economic

survey that could be accessed at any time for fishers to provide more information on the fishery, while Tails 'n' Scales have an end of season survey (send via email on the survey monkey platform) to gain stakeholder feedback that could also be integrated into the app.

Fishers respond to opportunities and the establishment of narrative that is marketed to fishers is important for encouraging participation. The narrative created by Snapper Check developers is personal to the fishers, for example, the Snapper Check data is important to make better decisions for you (the fisher). The Fangstjournalen program also recommends a strong narrative is built to promote the program that focuses on the benefits to the stakeholders and empowers the role of fishers in data collection, such as fishers can help collect information to navigate the way forward that can be used to evaluate regulations and maintain sustainable fisheries.

Key to the success of catch reporting programs is the development of real and measurable goals that can be clearly communicated to stakeholders (MyFishCount). An important aspect of the Snapper Check program is the director and chief scientist are available to take feedback directly from fishers. In the Tails 'n' Scales program, managers provide weekly catch updates through-out the seasons that are published online. Users of the Fangstjournalen reporting program receive a weekly report that is automatically generated detailing the number of app users, catch reports and fishing trips. Although time consuming, investment in developing a feedback system is important for becoming aware and resolving technical issues, responding to queries, and reducing social media backlash that can affect institutional integrity. The establishment of a two-directional dialogue system, where fishers receive information and feedback from their data, is fundamental for the long-term success of recreational catch reporting programs.

5. Bias and Data Accuracy

The review of the Victorian recreational rock lobster tagging program and VicRLTag app provides an opportunity to identify possible biases or inconsistencies that influence the data and design more robust data collection methods.

5.1 Inaccurate Reporting

Unintentional errors, deliberate or strategic misreporting, and/or incomplete information will affect the quality of data obtained. While there will always be some error involved in self-reported data, a well-designed reporting program and large samples size can reduce the influence of inaccurate reporting and provide valuable information (Joirle et al. 2016). In the VicRLTag program, for example, lobster weights are often reported interchangeably in grams and kilograms. Rock lobster weight data required cleaning and outliers excluded before analyses. Greater clarification, such as standardised units, for fishers may assist in removing some unintentionally misreported lobster weights. Likewise, fisher age (date of birth) is, in some cases, listed as 1 year old in the VicRLTag program. Restricting the possible age provided to a minimum of 18 (below which age they are exempt) and providing a clear data privacy policy could encourage fishers to accurately report. However, inaccurate reporting also includes non-reporting which is discussed in further details below. Given the current absence of a validation method for the data obtained in the VicRLTag app, the magnitude and influence of inaccurate reporting on recreational catch estimates, which is the primary objective of the program, is unknown. However, inaccurate reporting can be a major issue for even mandatory catch reporting apps, such as Snapper Check, as discussed in the 'implementation of catch reporting programs' section.

5.2 Non-response / Non-compliance Bias

Non-response bias occurs when fishers forget, neglect, or fail to adequately respond and, ideally, reporting processes should be developed with the intention to maximise participation and response rates (van der Hammen et al. 2016). Comparative and validation studies using traditional surveys are recommended best-practice to quantify and mitigate bias in fisher reporting (Venturelli et al. 2016). Currently, there is no validation method in place for assessing non-reporting in the VicRLTag app. Streamlining the current two-step reporting process (tag and report) in the VicRLTag program into one step could contribute to mitigating non-response bias by reducing the likelihood of tagged catch not being reported (that is, the second of the two-step process – the reporting of tagged catch). Initiatives that encourage increased compliance, such as the incentive features in Table 1, may need to be considered to mitigate non-reporting bias. Compliance in the VicRLTag app is assessed by compliance officer checks which are compared to catch reports at the end of the season. However, in the 2019/20 season compliance officers checked just 132 of 4395 (3%) VicRLTag catch reports of which 76% were subsequently reported and only 24% of these had accurate carapace length reported.

5.3 Selection Bias / Non-random Selection Bias

Selection bias occurs when a self-selected sub-sample is non-representative of the whole population. Selection bias is more pronounced in voluntary apps where data may be skewed towards a particular group of fishers and not representative of the overall trends of the fishery. As the VicRLTag program is compulsory (used tags (catch) are required to be reported by all fishers if not by app or by another method), non-random participation bias is less likely to influence the data compared to voluntary programs. However, differences in the accuracy of reporting methods (app to mail or phone) may exist. This was tested by Stunz et al. (2014) between app and creel surveys and Papenfuss et al. (2015) between app and mail surveys. These studies found similar catch data was obtained with apps at a reduced cost and with higher data resolution, however, the different methods could be used complimentarily. Further, the verification of demographic data obtained from apps has not been assessed, but it is acknowledged that demographic data obtained by apps could provide valuable insights into fishing behaviour (Papenfuss et al. 2015, Venturelli et al. 2016). For example, the social and economic survey available for fishers to complete in iSnapper, which includes questions on vessel used, discards and the condition of fish released. The voluntary citizen science component of VicRLTag could be susceptible to selection bias, which can be minimised with larger sample sizes or greater participation. Currently, only about 10% of participants have opt-ed into the citizen science program and of this only half have reported tag usage (VFA 2020). Therefore, encouraging participation in the citizen science program, which increases the sample size, can assist in mitigating the impact of selection bias on the data.

5.4 Avidity Bias

Avidity bias occurs when enthusiastic fishers skew the data to be non-representative of the overall fishery trends. In the VicRLTag program, fishers voluntarily sharing additional information or opting into the citizen science program are likely representing keen fishers rather than more opportunistic or infrequent fishers. The effects of avidity on the catch apps used in compulsory reporting programs, such as VicRLTag, should be minimal compared with volunteer reporting apps (Joirle et al. 2016). There is a broad range of avidity in VicRLTag users with most fishers using less than 10 tags a season, however, there are participants that use over 40 tags a year. The citizen scientists have a higher rate of active accounts that report tags (50%) than participants who are not in the program (24%), indicating that avidity and greater motivation to fish for rock lobster may influence citizen science data

(VFA 2020). Generally, participants in citizen science programs are more avid and skilled fishers and the data obtained is not representative of the overall fishery without correction (Gundelund et al. 2020).

5.5 Recruitment and Retention of Participants

In a compulsory catch reporting program, such as VicRLTag, participation rate and retention bias can be largely overlooked by the assumption that all participants report all catch (Joirle et al. 2016). In practice, it is unlikely that all trips are reported, and the uncertainty around the number would be difficult to gauge in many programs. Venturelli et al. (2016) suggest easy, fun, and social-media integrated apps can increase recruitment and retention of participants when there is a high reporting rate. This approach is consistent with the gamification of recreational fishing apps which has been used to increase public interest in science outreach programs including surveys (Brick 2018). Currently, in VicRLTag it is difficult to track retention rates as the only unique identifier for an account is an email address that can change over time and create duplicate accounts. However, the low rate of active accounts and the number of late reports that come in at the end of the season indicate that retention is an ongoing challenge for VicRLTag app. Collection and investigation of app user metrics can be useful for identifying the visitation rates and usability of the reporting process for prioritising future development and advancements.

5.6 Recall Bias

A participant's inability to accurately recollect events after-the-fact is known as recall bias, which is common in fisheries surveys and self-reporting programs, when there is a delay between the event and the reporting of the event (McCormack et al. 2013). Mechanisms that reduce the time between the event and reporting, such as near real-time reporting of catch, may reduce the occurrence of recall bias in catch reporting apps. In the VicRLTag program some tags are reported to have been used in the closed season and further analysis of these records show that the tags were reported at the start of the next season as fishers are placing orders for new tags. This indicates a recall bias where fishers were unsure of the date fished in the previous season, however, wish to report tags to obtain tags for the new season. The current requirement is for VicRLTag users to report used tags and reconcile remaining tags as lost or unused at the end of each season. Mechanisms that encourage participants to report on the day of fishing can reduce the impact of recall bias on the catch data reported, such as a same day (12.01 – 12.00) reporting requirement.

6. Fisher Surveys

The methodology applied for the three fisher surveys conducted in this project is based on that used successfully in previous surveys conducted for the Tasmanian recreational rock lobster and abalone fisheries (Lyle et al. 2019) that were independently reviewed by Pollock (2010). The design adapted for the Victorian recreational rock lobster fishery involved two-stages, the first stage involved an *initial survey* of rock lobster fishers to provide a range of information about the fishery as well as providing background information to assist in the development of the second stage, the *telephone-diary survey* to cover the peak of the 2020/21 fishing season (from season open on 16th November 2020 to 30th March 2021). The telephone-diary survey comprised a screening survey to assess survey eligibility, 2) a diary survey to monitor fishing activity in detail and 3) a wash-up or wrap-up survey in which fishers' attitudes and opinions to fisheries issues were assessed. The surveys were administered by a team of experienced phone interviewers.

6.1 Initial Survey

The survey was conducted by telephone during August/September 2020 and was based on a structured questionnaire in which respondents were asked a series of questions related to their experiences fishing for rock lobster in Victoria, including catch and effort in the 2019/20 season, satisfaction with the quality of the fishery, impacts of the 2019/20 bushfires and Covid-19 pandemic, and their participation in the tagging program.

6.1.1 Survey Sample

The survey sample in the initial survey was selected from fishers who had registered with the Victorian Fisheries Authority to fish for lobster in the 2019/20 season. Survey participants were randomly selected using geographically proportional representation to cover the spread of fishers by postcode across Victoria. The sample was further split evenly between fisher accounts that had previously reported tag usage in any year and those for which no tag usage had been reported.

6.1.2 Response Rates

In the initial survey, from a gross sample of 399 registered tag accountholders, all but 14 had valid phone contact details, resulting in a net sample of 385. Survey responses were obtained from 335 accountholders, representing a survey response rate of 87%.

6.1.3 Victorian Recreational Rock Lobster Fishery

A sample of Victorian recreational rock lobster fishers was selected to include an equal split of participants who had registered for but not reported tag usage (not fished) and those who had reported tag usage (fished). The average experience fishing for rock lobster in Victoria was nine years for respondents who had not fished and 14 years for respondents who had fished (Figure 3).

Over half (51%) of the respondents reported having registered for tags in all three seasons of the program, 24% had registered for two of the three seasons and 25% for only one of the three seasons. The majority (66%) of respondents fished in each of the seasons they were registered, 16% fished in some of the seasons while 18% had not fished for rock lobster in any of the seasons they had registered for.

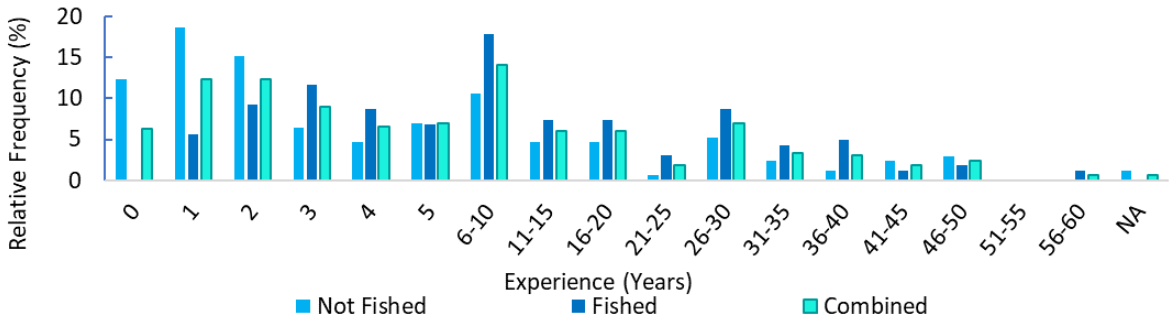


Figure 3: *Years of experience fishing for rock lobster in Victoria survey respondents, as a percentage of the total survey sample. NA not answered.*

6.1.4 Fisher Satisfaction with the 2019/20 Season

Respondents who indicated that they had fished for rock lobster during the 2019/20 season (regardless of whether they caught any lobster or not) were asked whether they were satisfied with the overall quality of the fishery. Fisher satisfaction with the 2019/20 season was high among respondents that fished for rock lobster, with 72% of respondents either very satisfied or quite satisfied with the quality of the fishery (Figure 4). For the 17% of respondents who were not satisfied

or not at all satisfied, 81% indicated that their dissatisfaction came from issues around the low abundance of legal sized lobster and difficulties in catching rock lobster.

The majority of respondents (57%) indicated that the proportion of successful trips (i.e., trips in which at least one rock lobster was caught) was about the same as in previous years, and 10% thought that the proportion has increased. By contrast, 27% believed the proportion of successful trips had decreased on previous years, while the remaining 6% were unsure.

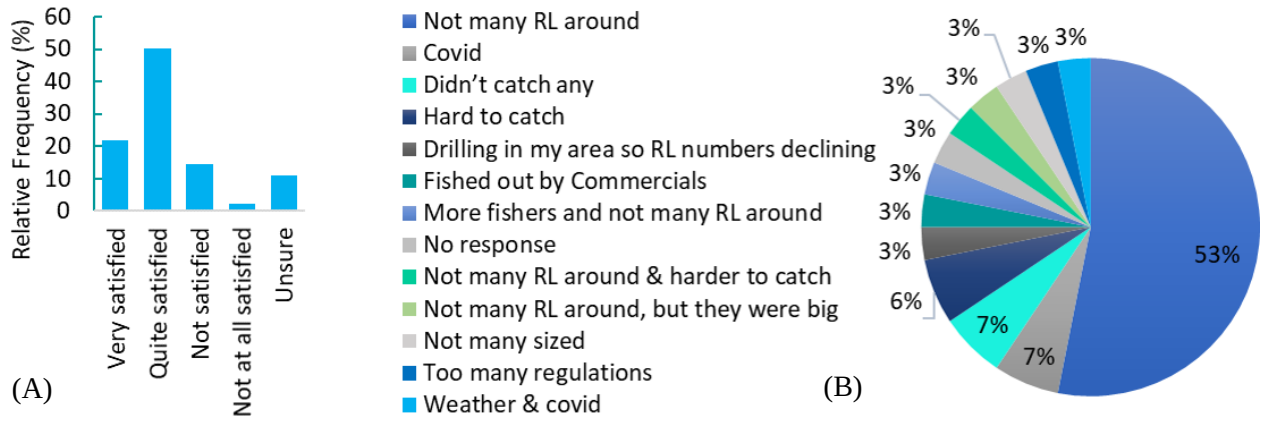


Figure 4: *(A) Fisher satisfaction with the quality of rock lobster fishing in the 2019/20 season; and (B) Reasons given for dissatisfaction.*

6.1.5 Impact of Bushfires and Pandemic on the 2019/20 Season

The survey provided an opportunity to gauge the impact of the bushfires and the COVID-19 pandemic on the 2019/20 fishing season. Only 17% of respondents stated that the bushfires had an impact on their rock lobster fishing, while for the remaining 83% there was little or no impact on their expected fishing activity for the season. COVID-19 restrictions had a greater impact on fishing, with 59% of respondents having cancelled planned fishing trips due to the pandemic, while the remaining 41% had no plans to fish.

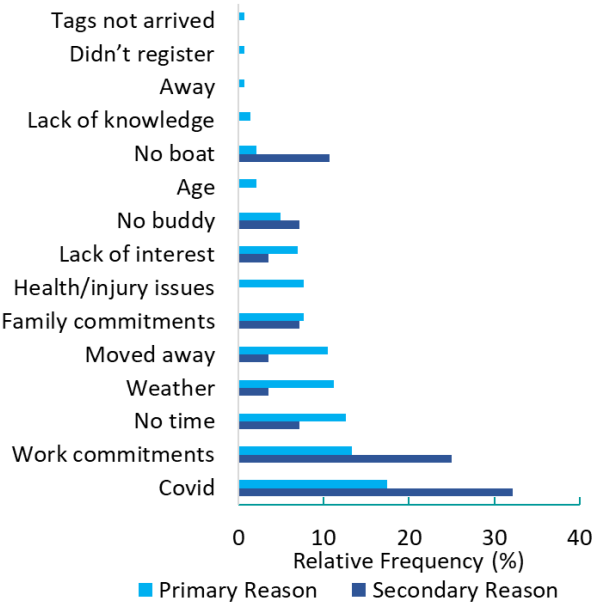


Figure 5: *Primary and secondary reasons registered Victorian recreational fishers did not fish for rock lobster in 2019/20 season.*

Of the responders who had not fished for rock lobster during 2019/20, COVID-19 was cited most often as either the primary (17%) or secondary (32%) reason for not fishing. Other reasons recreational fishers did not participate in the 2019/20 season included work commitments, a lack of time, and weather (Figure 5).

6.1.6 Catch, Effort and Catch Rate (2019/20 Season)

Respondents who fished in the 2019/20 season reported catching a total of 845 lobster based on 1397 fishing days, equivalent to an overall catch rate of 0.6 lobster/day.

The reported catch from the Eastern Zone was 389 lobster for 720 fishing days, representing a catch rate of 0.5 lobster/fishing day. Those respondents who fished in the Western Zone reported catching 456 lobster over 677 fishing days, at a catch rate of 0.7 lobster/fishing day.

Respondents who fished in the 2019/20 season reported catching five lobster on average in the Eastern Zone and six lobster in the Western Zone (Figure 6). The average days fished in both the Eastern and Western Zones was seven days. Although most respondents reported fishing in only one

management zone (48% fished in the Eastern Zone, 43% in the Western Zone) a small proportion (9%) reported fishing in both the Eastern and Western Zones.

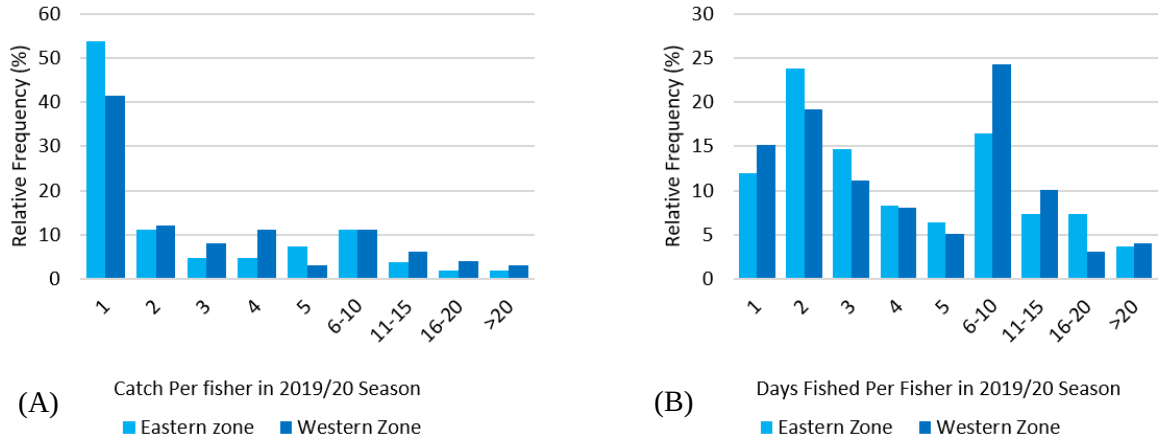


Figure 6: *(A) Number of rock lobster caught per survey respondent in the Eastern and Western Zones; and (B) number of days fished per survey respondent in the Eastern and Western Zones in the 2019/20 season.*

6.1.7 Compliance Checks and Catch Reporting

Of the respondents who fished for rock lobster in the 2019/20 season, 31% had a compliance check of their tags during the season. Although most respondents (73%) who fished in 2019/20 confirmed that they had never forgotten to report tags, 20% of respondents did indicate that they may have forgotten to report some tags as lost, used, unused or not used (Figure 7).

Thirty-two percent of respondents who fished stated that they had occasionally delayed reporting (by several days or weeks) used tags, while 68% indicated they never delayed reporting used tags. Most respondents (80%) who fished in 2019/20 stated they were unaware of other fishers either not tagging their lobsters or not reporting used tags, whereas 16% indicated that they were aware of other fishers not reporting tags while 4% were unsure. When asked to gauge the likely occurrence of non-reporting in the fishery, most respondents thought it was an occasional (41%) or common (26%) issue, while 18% thought it rarely occurred, and 15% were unsure (Figure 7).

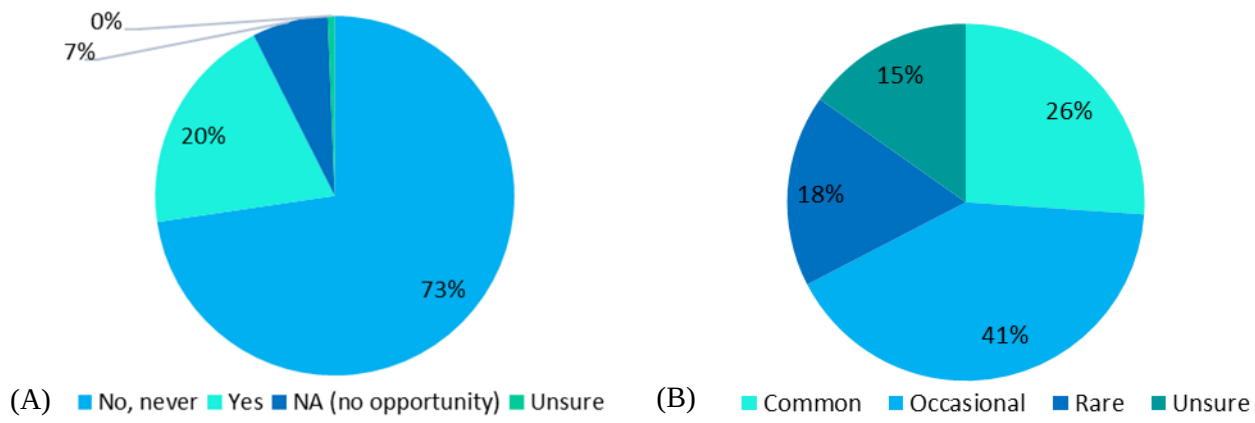


Figure 7: *(A) Proportion of respondents who had and had not forgotten to report tags; and (B) perceived level of occurrence of non-reporting by survey respondent.*

6.1.8 Recreational Rock Lobster Tagging Program

Respondents were informed that the tagging program had been introduced to provide information about the number of people who recreationally fish for lobster in Victoria and their catch, the numbers of lobster caught being determined by the number of tags reported as used. Furthermore, they were advised that this information was to be used to help sustainably manage the fishery for commercial and recreational sectors. Over 95% of respondents reported being aware of the reasons the rock lobster tagging program was implemented and most (72%) thought the benefits of the tagging program were adequately communicated. However, 20% indicated that more needed to be done to communicate the benefits, while 8% of respondents were unsure.

Only 6% of respondents were aware of and had participated in the citizen science program, while a further 36% indicated some awareness of the program. The majority (58%) were, however, unaware of the program, suggesting that opportunities exist to better communicate and incentivise participation in the citizen science program (Figure 8).

Generally, respondents considered the catch data reported in the tagging program to be accurate (48%) or at least indicative (30%), only 5% thought the data was inaccurate, with 17% of respondents being unsure as to the data quality.

General satisfaction with the rock lobster tagging program was high, with 87% of respondents either very or quite satisfied compared with 9% who were either unsatisfied or not at all satisfied and 4% who were unsure (Figure 9). Overall, most respondents (55%) indicated that both the tags and app were easy to use (amongst respondents who had fished in 2019/20 this approval was as high as 90%), 5% considered one component was easy but not the other and fewer than 1% of respondents thought both components were difficult apply (Figure 8). Most of the remaining respondents (38%) indicated that they were yet to use the tags or app.

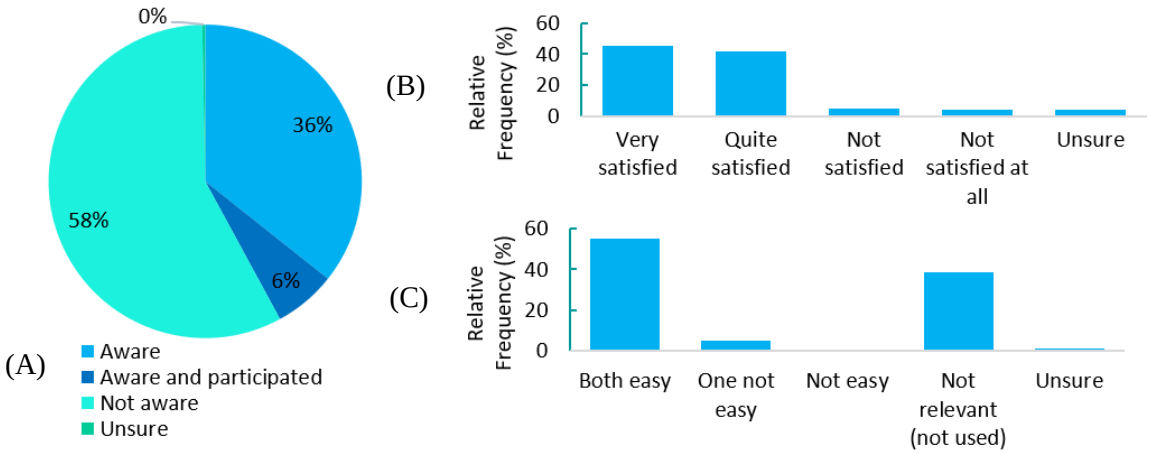


Figure 8: *(A) Respondent awareness of the citizen science initiative within the Victorian recreational rock lobster tagging program; (B) Overall respondent satisfaction with the tagging program, and (C) ease of using the tags and app.*

6.1.9 Comparison with VicRLTag Reports

Respondents were asked to estimate the number of rock lobster that they had caught to date during the 2019/20 season, these estimates were then matched with tag usage data reported in the VicRLTag program for the corresponding period. Overall, 133 (39.7%) of the survey respondents reported catch numbers (including zero catches) that did not match their records reported in the VicRLTag program, 63 of these respondents reported fishing in the Eastern Zone and 70 had fished in the Western Zone (Figure 9). Such differences are not unexpected, since survey respondents were asked to recall how many rock lobster they had caught since the start of the season (some 9-10 months prior) and recall bias is well established issue. However, reporting of tag usage is mandatory and if high compliance rates are assumed, the VicRLTag records are expected to be more accurate. As highlighted, although there were differences, catch reports were consistent in the majority of cases with 81% of respondents in the Eastern Zone and 79% of respondents in the Western Zone having no difference in the catch reported in the initial survey to that reported in VicRLTag. Overall,

there were 266 lobsters in the Eastern Zone and 323 lobsters in the Western Zone reported by respondents in the survey that were not reported to VicRLTag. Although the majority of discrepancies were minor (small number of lobsters) and may be linked to recall issues rather than deliberate misreporting, two respondents did report over 45 lobster each that they suggested were deliberately not reported to VicRLTag.

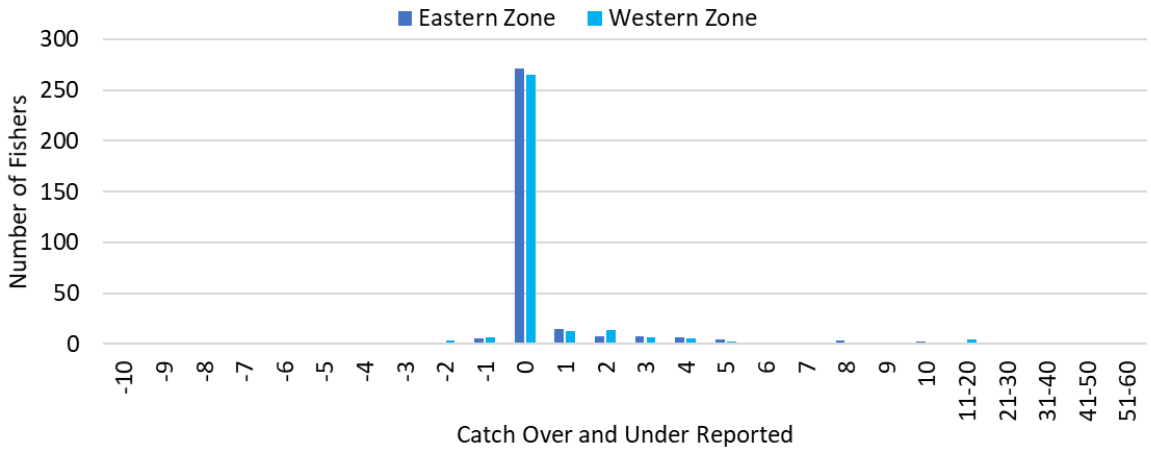


Figure 9 *The over-reporting (negative) of catch by respondents in VicRLTag compared to the diary survey and the under-reporting of catch in VicRLTag compared with the diary survey (positive).*

6.2 Diary Survey

The telephone diary survey was conducted in three parts: a screening survey to assess eligibility the of potential participants followed by a diary survey that recorded details of a respondents fishing events during the survey period and a wash-up survey to assess attitudes and opinions relevant to the fishery.

6.2.1 Survey Sample

A sample of fishers registered with the Victorian Fisheries Authority to fish for lobster in 2019/20 was selected for the telephone-diary survey. The registration database was first stratified according to Australian Bureau of Statistics (ABS) Statistical Area Level 4 (SA4) classifications and then within each of these strata, fishers were grouped into those who had reported tag usage during 2019/20

("active" fishers) and those who had not made any reports[1]. The survey sample was then based on random selection, with a higher sampling rate (about three times higher) amongst those who had reported tag usage during 2019/20, compared with those who had not reported using tags[2]. The rationale for this stratification was to ensure that a sufficient sample of "active" fishers was included in the survey sample[3]. For analysis, five regional strata were recognised, some involving multiple SA4s, they are Warrnambool and Southwest (SA4 217), Geelong (SA4 203), Latrobe – Gippsland/Mornington Peninsula (SA4s 205, 214), Eastern Metro/Hume (SA4s 204, 206-209, 211-212), and Western Metro/Inland Western Victoria (SA4s 201-202, 210,213, 215-216) (Figure 10).

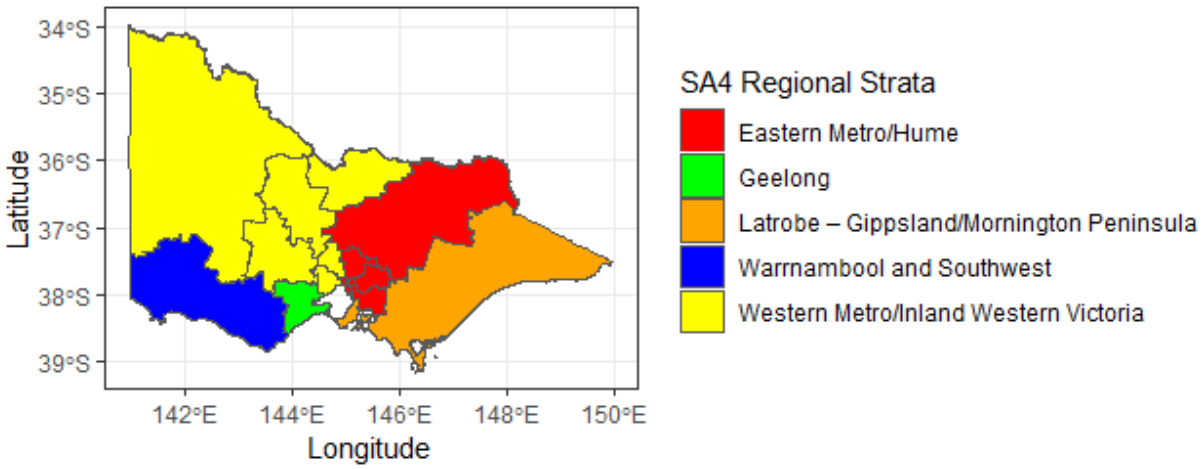


Figure 10 *The regional strata derived from ABS SA4 classifications used in the diary survey.*

6.2.2 Screening Survey

The screening survey was conducted in October 2020. Respondents were asked questions about their fishing behaviour in the 2019/20 season and their intentions to register for rock lobster tags for the 2020/21 season. Respondents who expressed an intention to register to fish for rock lobster in the 2020/21 season were considered eligible for the diary survey.

[1] Interstate residents, representing about 1% of all registered fishers, were excluded from sample selection,
[2] To reduce potential respondent burden, any fishers selected for the diary survey sample who had been included in the initial survey sample were replaced using random selection.
[3] Note: during 2019-20 only 17% of registered fishers reported tag usage.

6.2.3 Diary Survey Methods

Eligible respondents were invited to participate in the diary survey, which commenced at the opening of the season on 16th November 2020 and closed 31st March 2021. Those who agreed to participate in the diary survey were mailed a simple diary and letter of introduction. Diarists were contacted by telephone shortly afterwards to confirm receipt of their survey kit and have reporting requirements explained. Diarists were then contacted regularly by telephone throughout the survey period by experienced interviewers who recorded details of any rock lobster fishing activity since last contact. The frequency of the contact was tailored to the needs and behaviour (level of fishing activity) of individual respondents and thus detailed information was routinely collected soon after each fishing event, minimising recall bias for any non-diarised data. By maintaining regular contact, typically at least once a month, interviewers were also able to clarify any misunderstandings or inconsistencies at the time of the interview, thereby maximising overall data quality and completeness.

Respondents were asked to keep a record of the date, location, fishing platform (boat- or shore-based), hours fished, fishing method (snorkel, scuba, hookah, or hoop net) and species targeted for all successful and unsuccessful rock lobster fishing trips. For a successful catch, diarists were also asked for the numbers of each species personally caught and the carapace length (CL) and sex of any rock lobster retained.

By definition, a fishing event was described in terms of method and fishing region (Figure 11). If more than one method was used or different regions were fished on a given day, separate events were recorded. For example, two separate events were recorded if a respondent used a hoop net and dived for lobster on the same day, with catch and effort information linked separately to each method.

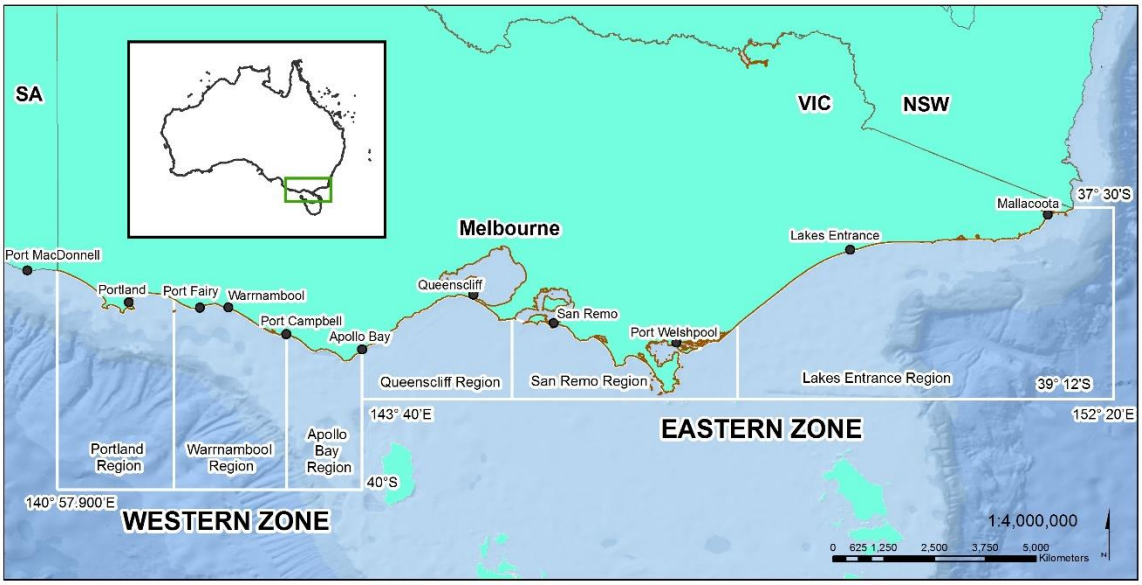


Figure 11 *The Western and Eastern Zones in the Victorian Rock Lobster Fishery which consist of three regions – Portland, Warrnambool and Apollo Bay regions in the Western Zone and Queenscliff, San Remo and Lakes Entrance regions in the Eastern Zone. Map courtesy of VFA.*

6.2.3a Average Lobster Weight

The estimated average lobster weight was calculated using the carapace length (CL) reported by diarists. The CL was associated with a weight from the longstanding length-weight relationship used in the Victorian rock lobster stock assessment. Lengths were converted to weights using the following relationship:

Male	**Female**
7^{-07}*length$^{2.9221}$	2^{-06}*length$^{2.7535}$

6.2.3b Comparison to VicRLTag reports

Rock lobster catch numbers reported by individual diarists were compared with reported tag usage by the same respondent on the VicRLTag app during the survey period (November 2020 to March 2021). Discrepancies are expected since diary reporting is voluntary whereas reporting requirements for VicRLTag, although mandatory, allow for reporting of tag usage after the event and up until the end of the season. Nonetheless, this analysis does provide a unique opportunity to compare the alternative approaches to monitoring catch and effort.

6.2.4 Response Rate

A random sample of 448 recreational rock lobster fishers was selected (gross sample) from the 2019/20 VicRLTag database of 5711 registered recreational rock lobster fishers (sample population) (Table 3). Sample loss (disconnected or incorrect phone numbers) reduced the effective (net) sample to 436, from which full responses to the screening survey was achieved from 381 respondents, representing an overall response rate of 87%. Based on whether fishers had reported tag usage during 2019/20, and consistent with sample design, the screening survey sample was weighted to "active" fishers, with 15% (or about one in seven) fishers who reported tag usage in 2019/20, compared with 5% (one in twenty) who did not report catching any rock lobster in 2019/20 responding to the screening survey.

Of the respondents who completed the screening survey, 348 indicated they were likely to re-register for rock lobster fishing in the 2020/21 season and, consequently, were eligible to participate in the diary survey. A total of 298 respondents accepted the diary with 270 (91%) completing the diary survey component. Based on diary eligible respondents, this represented an overall diary completion rate of 78%, with virtually no variation in the completion rates for fishers who did or di not report tag usage during 2019/20.

Of those respondents who competed the diary survey, 263 were available for the wash-up survey. Note, at this time some diary completers had gone out of scope, for example moved interstate with no intention to fish for rock lobster again within the survey period. Full responses to the wash-up survey were achieved from 97% (254) of the available diarists.

Table 3 Telephone diary survey sample and response details.

		Total	No tags reported used in 2019/20	Tag usage reported in 2019/20
	No. registered fishers	5711	4738	973
Screening survey	Gross sample	448	279	169
	Sample loss	12	8	4
	Net sample	436	271	165
	Full response	381	234	147
	Non-response	56	30	26
	Non-contact	36	24	12
	Response rate (%)	87.4	86.3	89.1

	% registered fishers	6.7	4.9	15.1
Diary survey	Eligible for diary	348	204	144
	Accept diary	298	177	121
	Complete diary	270	158	112
	% eligible diary complete	77.6	77.5	77.8
	% accepted diary complete	90.6	89.3	92.6

6.2.5 Screening Survey Results

Of the 381 participants who fully responded to the screening survey, 283 (74%) indicated that they had fished for rock lobster in the 2019/20 season, of whom 179 (63%) were successful in catching at least one rock lobster.

Screening survey respondents reported a total of 2002 days fishing for rock lobster, harvesting 1350 lobster in 2019/20. Of these, 903 fishing days and 581 lobsters caught were from the Eastern Zone, while 1099 fishing days and 769 lobsters caught were from the Western Zone.

When recalling catches the 2019/20 season, 145 respondents reported no catch in VicRLTag, but reported fishing for rock lobster in the screening survey. This totalled 666 days fished and 226 rock lobster caught by these respondents that was otherwise not reported. This comprised 334 days fished and 108 lobsters caught in the Eastern Zone and 332 days fished and 118 lobsters caught in the Western Zone.

Of the active fishers surveyed, 138 (93.9%) reported fishing for rock lobster during 2019/20 with 132 (89.8%) catching at least one rock lobster. Therefore, a small proportion of the fishers who reported tags used on the VicRLTag app during 2019/20 indicated in the screening survey that they had not caught any rock lobster. While the majority of fishers surveyed who had not reported tag usage during 2019/20 had, according to the screening survey, caught no rock lobster during 2019/20, 145 (62%) reported fishing for rock lobster with 47 (20.1%) catching at least one rock lobster. Although relatively minor, these discrepancies are likely to be influenced by reporting biases (principally issues associated with recall) in the telephone survey and potential compliance issues with tag reporting.

6.2.6 Diary Survey Results

Out of the 270 fully responding diarists, 200 (74%) were identified as registered in 2020/21. Amongst those diarists who reported no tag usage during 2019/20, only 94 (59.5%) re-registered for the 2020/21 season despite indicating that they were likely to renew their registration. By comparison, 106 (94.6%) of diarists who reported tag usage in 2019/20 re-registered in 2020/21.

Of the 70 diarists who did not re-register, 16 (22.9%) reported at least one rock lobster fishing event during diary period, three of these diarists (4.3%) reporting a combined total catch of eight rock lobster. Data for diarists not registered during 2020/21 as well as data for respondents who did not complete the full diary survey (16th November 2020 to 30th March 2021) have been excluded from subsequent catch and effort analyses.

6.2.6a Catch and Effort

During the study period diarists reported catching a total of 395 Southern Rock Lobster and one Eastern Rock Lobster based on 469 fishing events (460 fisher-days), representing 852.9 hours of targeted fishing effort. That is, fishing events averaged1.8 hours in duration, yielding a catch of 0.84 rock lobster per event (0.46 lobster per hour).

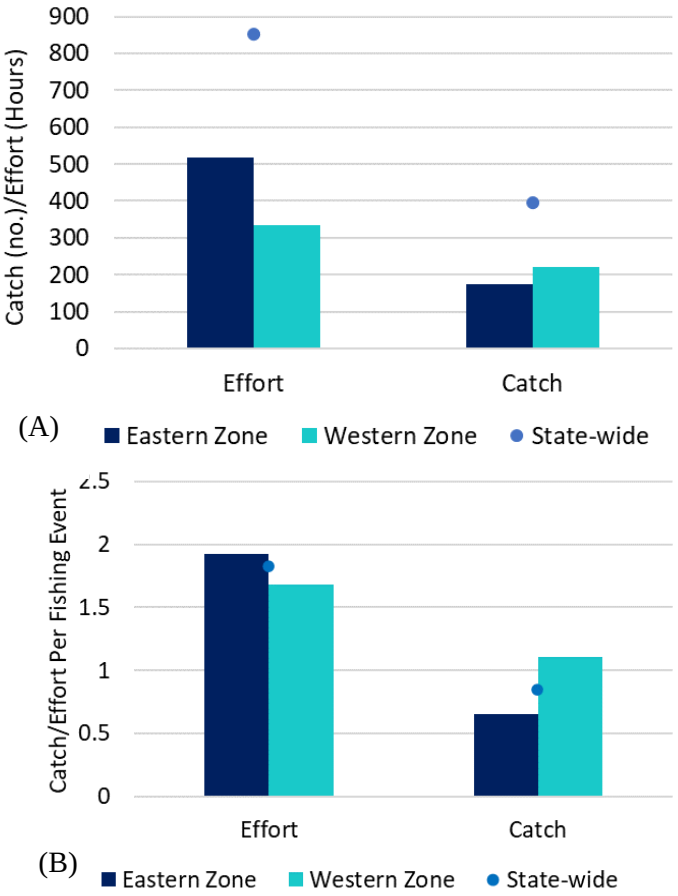


Figure 12 *The total effort (hours) and catch reported by diarists (A), and the average catch and effort per fishing event reported (B) in the Eastern Zone, Western Zone and State-wide.*

In the Eastern Zone, diarists reported 269 fishing events, representing 517 hours of effort and a catch of 175 lobster during the survey period (Figure 12). In the Western Zone, diarists reported less effort, 200 fishing events and total fishing time of 335.8 hours but had a higher catch of 221 lobster. In the Eastern Zone, on average 1.9 hours was spent fishing per event for a catch of 0.65 lobster (or 0.33 lobster per hour). In the Western Zone, events averaged 1.7 hours but resulted in higher catch rates, equivalent to 1.1 lobster per event (0.66 lobster per hour).

6.2.6b Regional Catch and Effort

Fishing effort (hours) was primarily concentrated in the Warrnambool (36%), Queenscliff (29.4%) and San Remo (29.5%) regions (Figure 13). Warrnambool (51.3%), Queenscliff (24.4%) and San Remo (19.4%) were also the regions with the highest proportions of catch taken by diarists. Effort was also primarily concentrated in the Warrnambool, Queenscliff and San Remo regions.

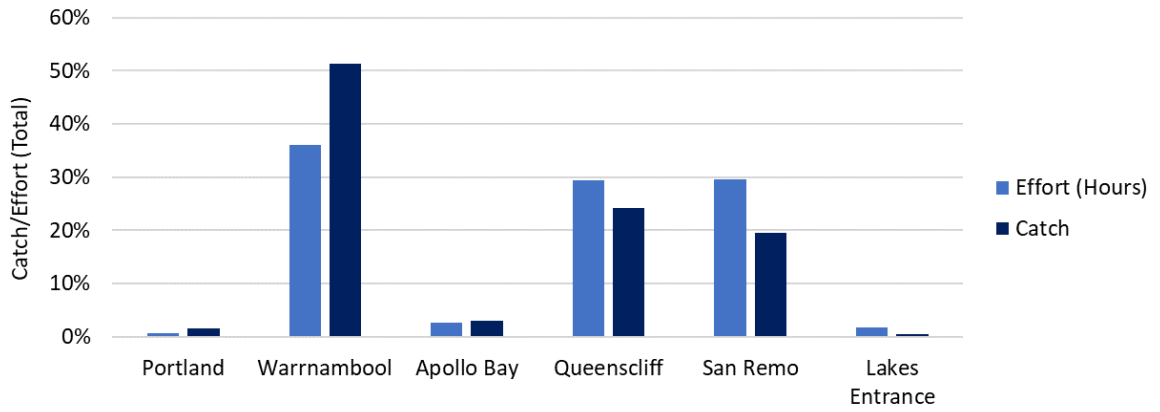
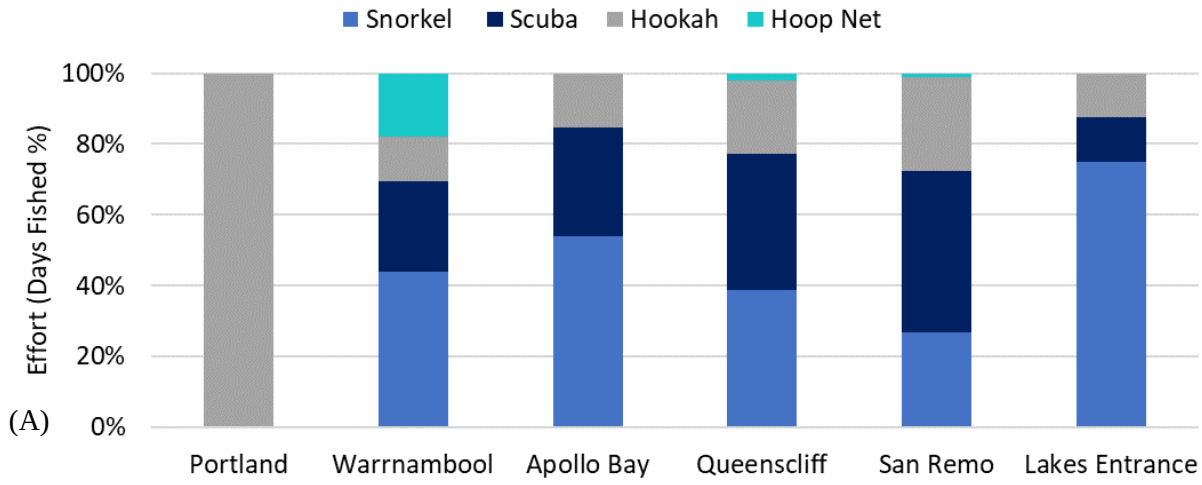


Figure 13 *The proportion of catch and effort (hours) reported by diarists over the survey by region.*

6.2.6c Fishing Method

The majority of effort (days fished) reported by diarist was dedicated to snorkel fishing (39%), followed by scuba fishing (34%) across Victoria. Snorkel had the largest number of days fished by diarists in both the Western Zone (44%) and scuba had the largest number of days fished in the Eastern Zone (41%). In the Eastern Zone, snorkel (35%) and hookah (23%) also had a high proportion of hours fished by diarists, while in the Western Zone, scuba (25%) were the second fishing method with the largest number of days fished (Figure 14). Lakes Entrance (75%) and Apollo Bay (53%) were the regions with the highest hours fished by snorkel, while Portland diarists exclusively used hookah.



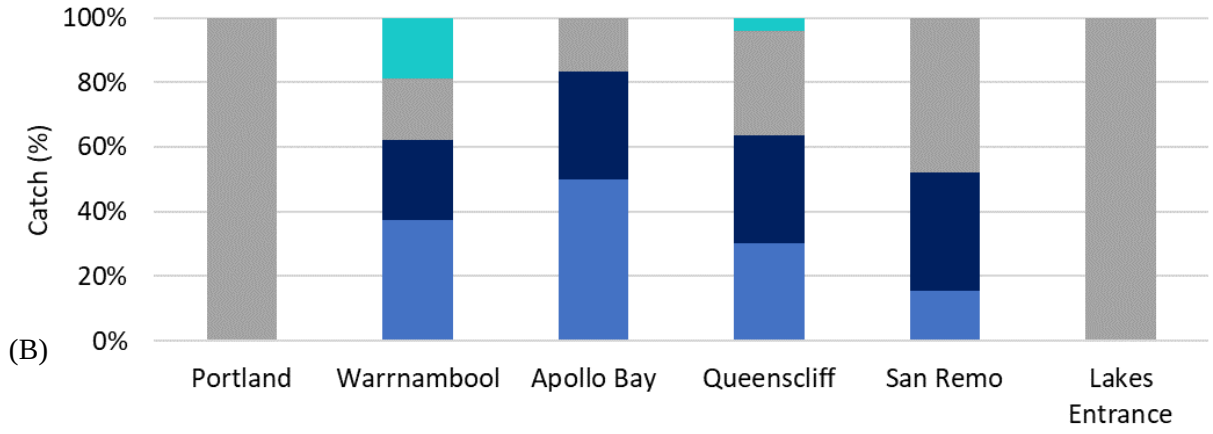


Figure 14 *The percentage of effort (hours) by fishing method in each region reported by diarists (A), and the percentage of catch taken by diarists by fishing method in each region (B).*

Most catch obtained by diarists across Victoria was harvested by divers using snorkel (31.1%), followed by hookah (29.5%) and scuba (28.8%). In the Eastern Zone, most of the catch came from hookah (40.0%) and scuba (34.3%) fishing. However, in the Western Zone, snorkel (37.1%) and scuba (24.4%) were the fishing methods with the highest catch obtained. Snorkel was the fishing method with the highest catch obtained at Apollo Bay (Figure 14). Hookah was fishing method with the highest proportion of catch (50% of catch) in San Remo (48.1%) and the only fishing method to obtain catch in Portland and Lakes Entrance (100% of catch each).

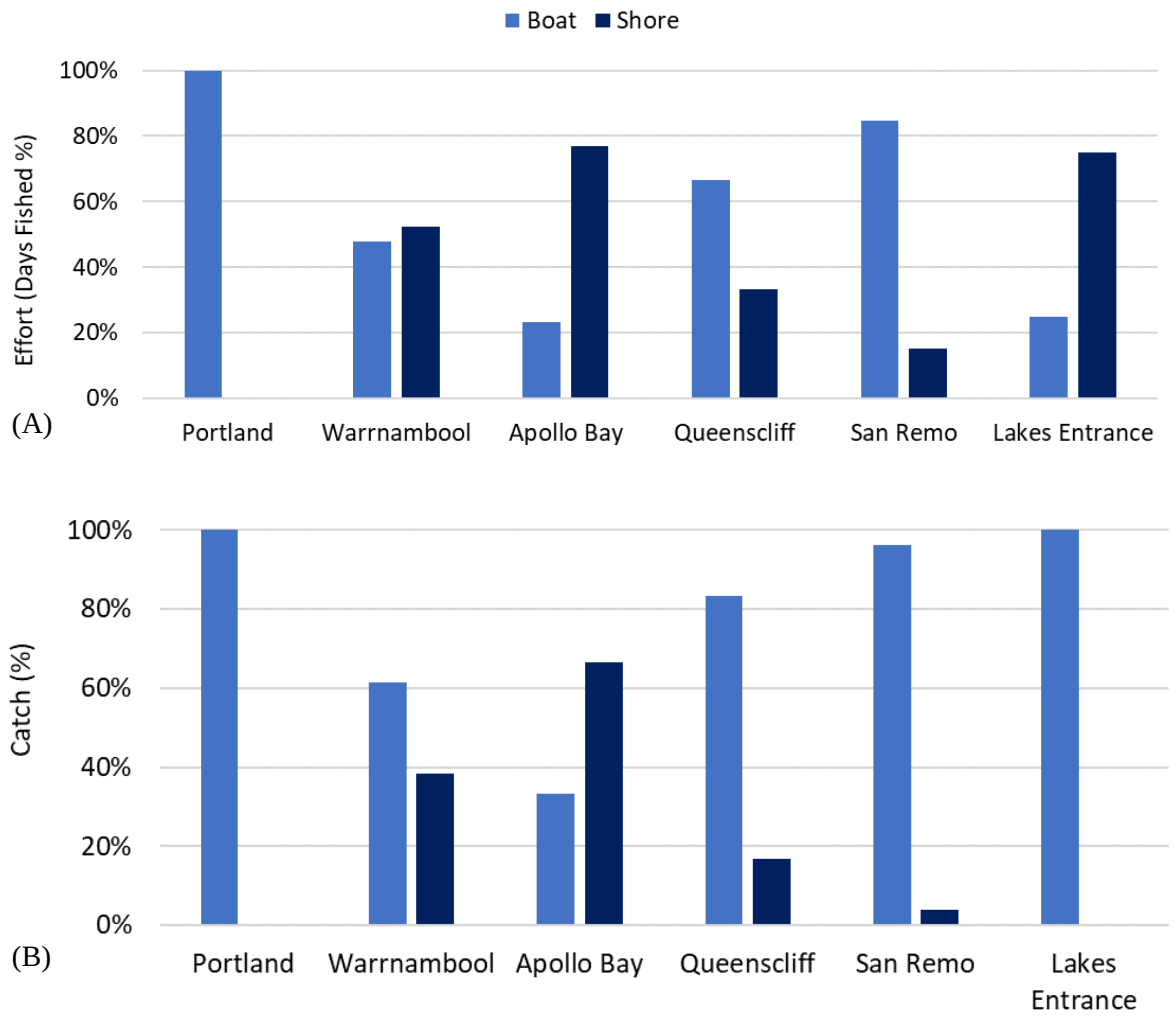
6.2.6d Fishing Platform

State-wide, targeted fishing effort (days fished) for lobster was dominated (62%) by boat-based compared to shore-based (38%) fishing activity (Figure 15). In the Eastern Zone, 73% of effort was boat-based, whereas in the Western Zone, effort was more evenly shared between boat (47%) and shore-based (52%) fishing activity. Of the regions, Portland had the highest effort for boat-based rock lobster fishing (100%) followed by San Remo (85%). Apollo Bay had the most effort shore shore-based fishing (77%) followed by Lakes Entrance (75%).

Most of lobster (73.5%) caught by diarists were taken by boat-based as opposed to shore-based fishing (26.5%). In the Eastern Zone 89.1% of lobsters caught were from boat-based fishing, while only 10.1% were caught from shore-based fishing. In the Western Zone, 61.1% of catch was caught by boat-based fishing and 38.9% of catch by diarists was from shore-based fishing. Portland (100%),

Lakes Entrance (100%), San Remo (96.1%) and Queenscliff (83.3%) were the regions with catch overwhelmingly caught from boat-based fishing (Figure 15). Apollo Bay was the only region where the shore-based catches exceeded that taken by boat-based fishing (66.7% shore-based).

The CPUE (catch/day fished), and therefore fishing success, was higher for boat-based fishing (1.15) compared to shore-based fishing (0.43). The Eastern Zone had lower CPUE for both boat-based (0.40) and shore-based (0.15) fishing compared to the Western Zone (0.95 for boat-based fishing and 0.44 for shore-based fishing). Portland was the region with the highest CPUE (1.50) followed by Warrnambool (1.45) and Apollo Bay (1.33) for boat-based fishing (Figure 15). Warrnambool and Apollo Bay had the highest CPUE for shore-based fishing (0.83 and 0.80 respectively).



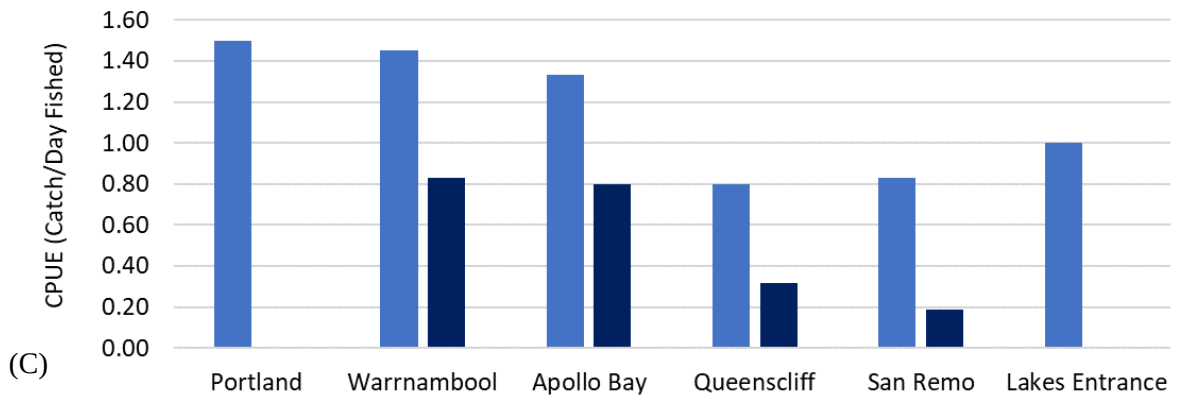


Figure 15 *The percentage of effort (hours) by boat- and shore- based fishing in each region (A), the percentage of successful trips by boat- and shore- based fishing in each region (B), and the catch per unit effort (CPUE catch/hour) in each region for boat- and shore- based fishing.*

6.2.6e Average Catch Per Fishing Trip

State-wide 51% of fishing trips reported by diarists resulted in zero catch (Figure 17). In the Eastern Zone 65% of fishing trips resulted in zero catch, whereas 35% of fishing trips in the Western Zone resulted in zero catch. Portland was the region with the highest percentage of trips resulting in the daily bag limit of 2 lobster being reached (75%), however, this was based on just 4 events that all used hookah as the fishing method. Overall, the proportion of trips that in which diarists reached the bag limit (2 lobster) was substantially higher in the Western Zone (55%) compared to the Eastern Zone (17%).

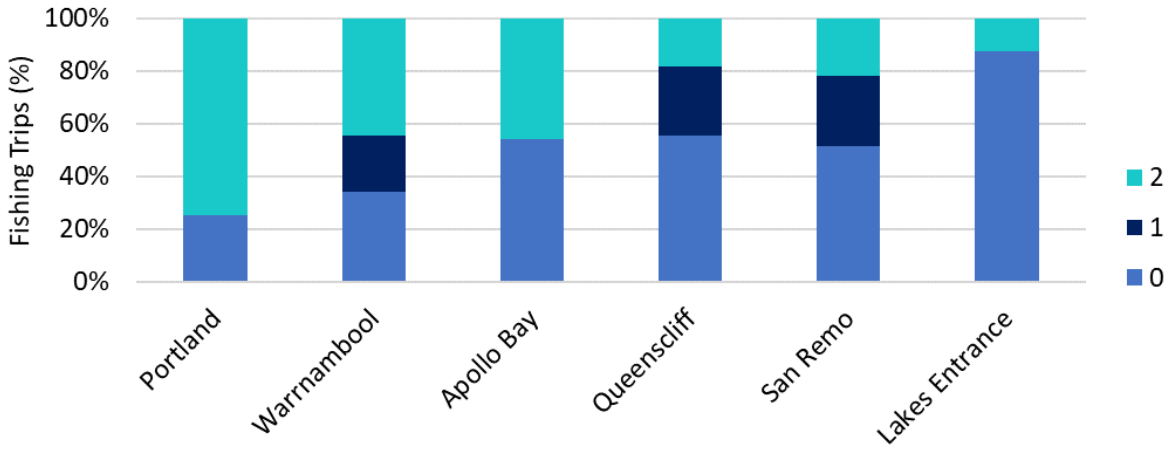
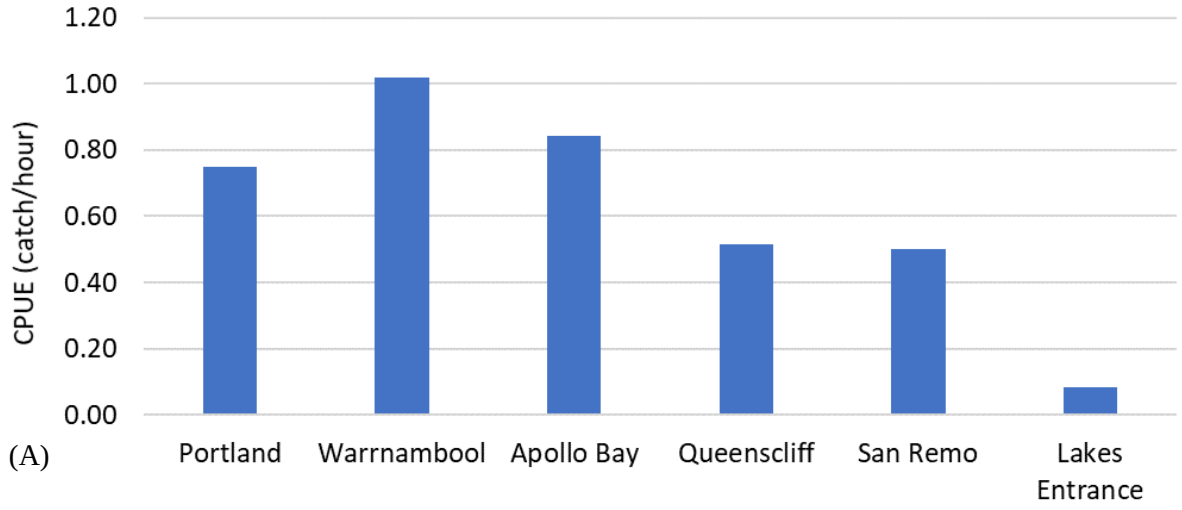


Figure 16 *The percentage of fishing trips in each region in which diarists caught zero, 1 or 2 lobsters.*

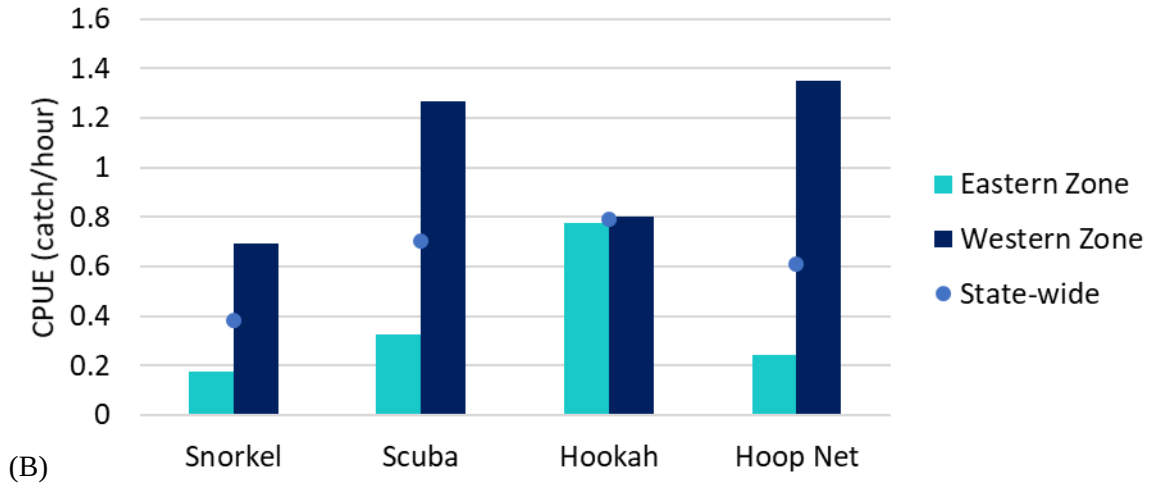
6.2.6f Catch Per Unit Effort (CPUE)

State-wide average CPUE, calculated from the reported catch and effort in diary survey and including zero catch fishing trips, was 0.71 lobster per hour, with the CPUE for the Western Zone (0.87) more than double that for the Eastern Zone (0.37). Regionally, Warrnambool had the highest CPUE (1.02), while Lakes Entrance had the lowest (0.08). The highest CPUE in the Eastern Zone was 0.52 in the Queenscliff region (Figure 17). The inclusion of zero catch fishing trips differs to inferences that can be made from the VicRLTag app reports that only include successful catch reports and thus results in inflated estimates of CPUE.

Of the various fishing methods, hoop nets had the highest CPUE (1.24) across Victoria (Figure 17). The high catch rate for hoop net was primarily from the Western Zone which had a higher CPUE compared to the Eastern Zone. Snorkel had the lowest CPUE (0.49) across Victoria and had the lowest CPUE by fishing method in both the Western Zone (0.69) and Eastern Zone (0.17).



(A)



(B)

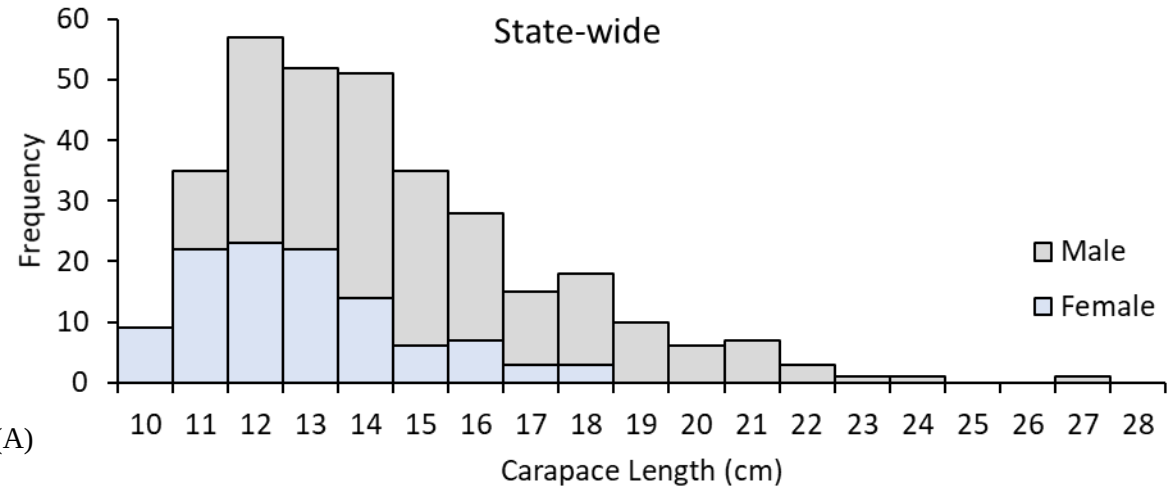
Figure 17 *The average catch per unit effort (catch/hour) in each region (A), the average catch per unit effort (catch/hour) by fishing method for the Eastern and Western management zone (B).*

6.2.6g Size Composition

Diarists provided the length and sex data for 329 lobsters during the survey period, which consisted of 109 females and 220 males. The average state-wide carapace length (CL) was 14.28 cm. The average CL of female lobster was 12.82 cm with a range between 10 and 18 cm. The average CL of male lobster was 15.01 cm with a range between 11 and 27 cm (Figure 18).

In the Eastern Zone, diarists reported the carapace lengths and sex of 133 lobster, represented by 58 female and 75 male lobster. The average CL in the Eastern Zone was 15.20 cm. Females averaged 13.72 cm (range of 10 to 18 cm) while males averaged16.33 cm (range of 11 to 27 cm) (Figure 18).

In the Western Zone, length and sex data for 196 lobsters were provided by diarists, of which 51 were female and 145 male. Overall, lobsters averaged 13.66 cm CL , or 11.78 cm (range 10 - 17 cm) for females and 14.32 cm (range 11-22 cm) for males (Figure 18).



(A)

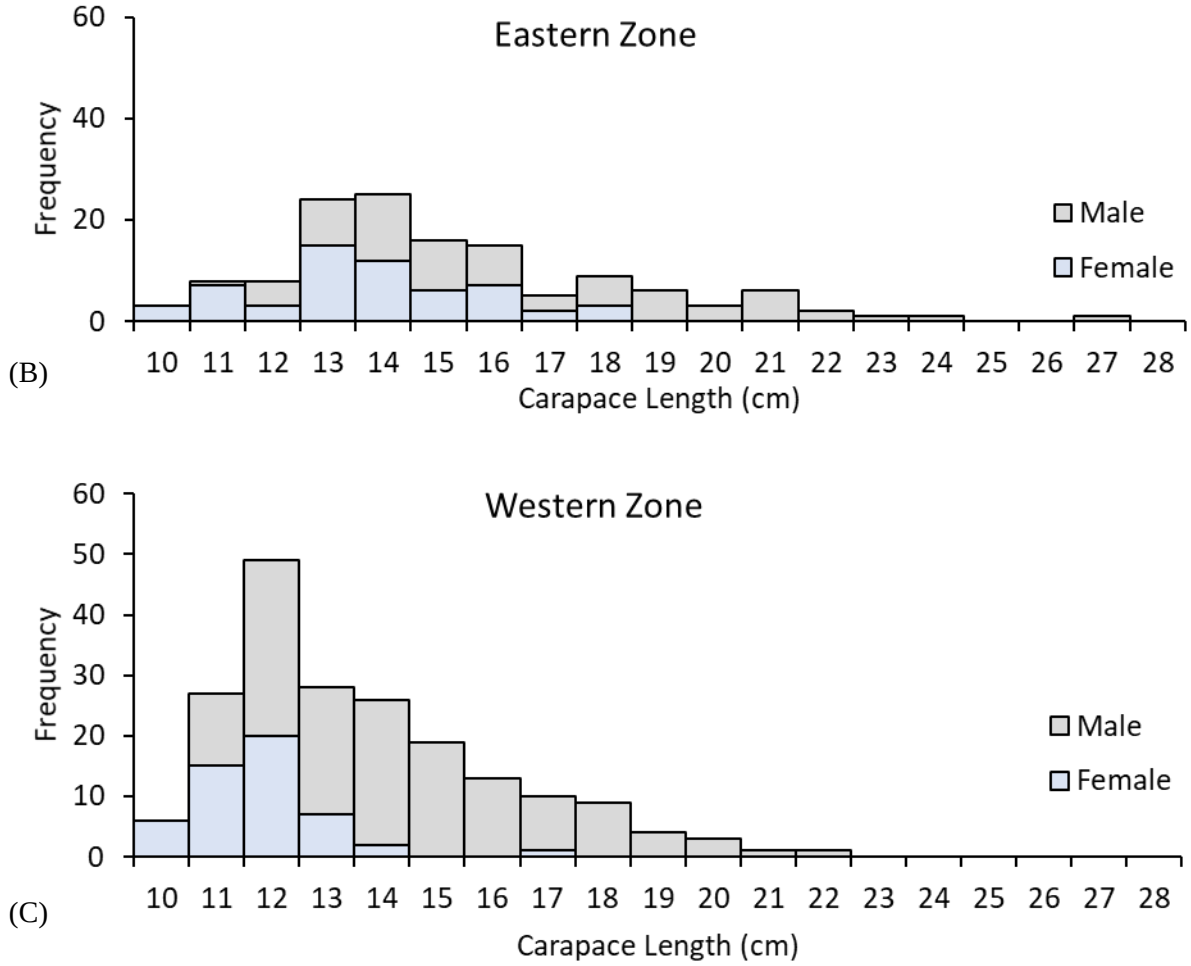


Figure 18 *The state-wide carapace length (CL) frequency distribution of catch reported in the diary survey, (B) the Eastern Zone carapace length (CL) frequency distribution of catch reported in the diary survey, and (C) the Western Zone carapace length (CL) frequency distribution of catch reported in the diary survey.*

6.2.6h Estimated Average Lobster Weight

Based on the sample of measured lobster, the overall average weight was 1.59 kg. Lobster weights in the Eastern Zone were on average 1.75 kg, which was higher than the Western Zone average of 1.43 kg.

Across Victoria, the largest average lobster weight was harvested by scuba diving (Figure 19). The largest average lobster weight was caught by snorkel in the Eastern Zone (2.31 kg), which was 1.2 kg higher than the average lobster weight caught by snorkel in the Western Zone (1.1 kg). The Western Zone had a higher average lobster weight for scuba (1.83 kg) and hookah (1.57 kg) then the Eastern Zone (1.79 and 1.56 kg, respectively).

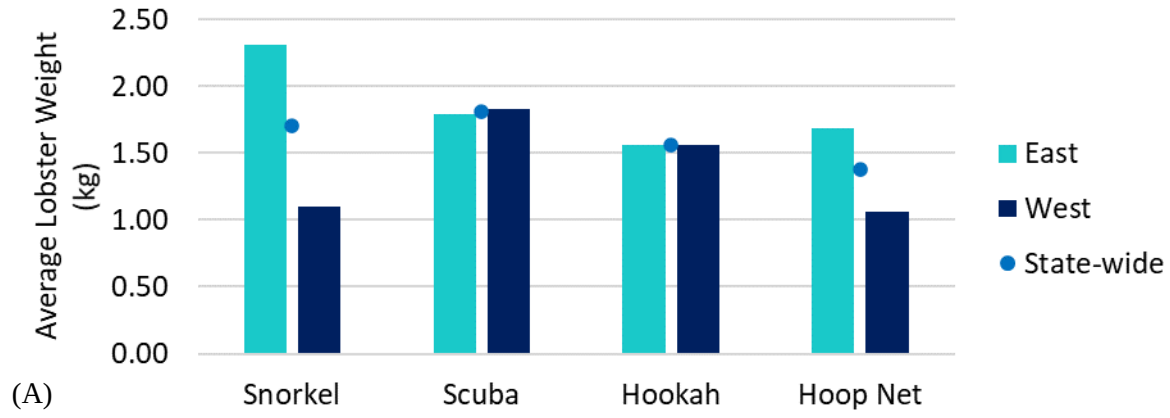


Figure 19 *The estimated average lobster weight by fishing method for the Eastern and Western zones and the state-wide average.*

6.2.6i Comparison to Catches Reported on VicRLTag

There was generally good alignment between lobster catch numbers reported in the diary survey and tag usage for the corresponding period reported to VicRLTag, with lobster catch numbers (including zeros) matching for 71% of the diarists registered for tags in 2020/21 (Figure 20). Signifiantly, all diarists who reported no fishing for lobster during the survey period (26.6%) also had no tag usage reports on VicRLTag.

In relation to the 147 diarists who reported fishing for lobster during the survey period, diary catch numbers matched reported tag usage in 60.5% of instances, whereas 32.6% of diarists reported catching more lobster than they had reported to VicRLTag while 6.8% reported fewer lobster. Where discrepancies were evident, the majority varied by ± 2 lobster, the greatest discrepany was for a respondent who reported catching 18 more lobster to the diary survey than reported to the VicRLTag app. Although it is not possible to determine whether catch discepancies reflect deliberate or non-intentional misreporting (over- or under-reporting to the diary survey or under-reporting of tag usage), it is worth noting that some registered rock lobster fishers do not typically report tag usage until sometime after the event (VFA 2020) and thus it is feasible that at least some of the apparent “over-reporting” of catches by diarists may simply be a consequence of delayed reporting of tag usage.

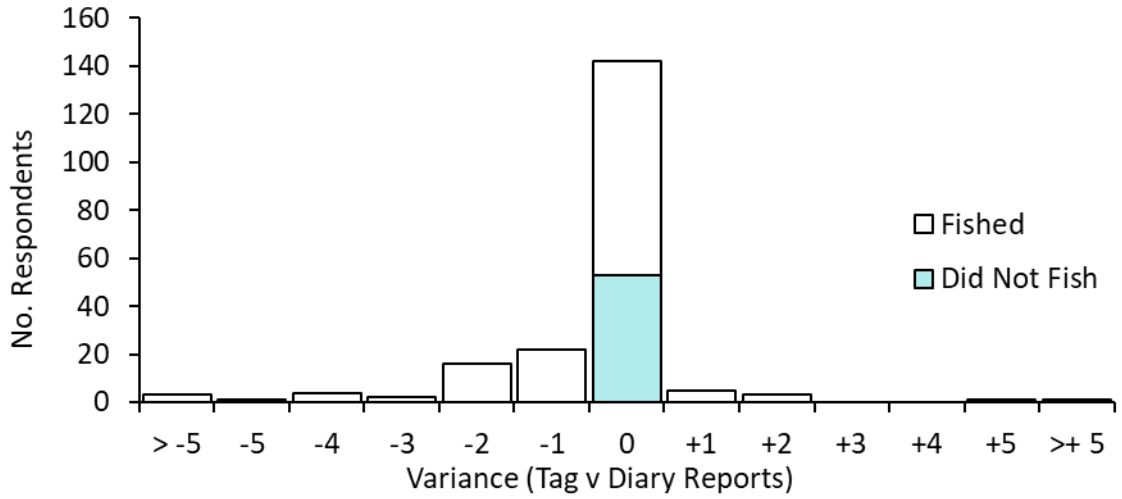


Figure 20 *The variance between catch reported by participants in the diary survey and catch reported by diarists in VicRLTag.*

6.2.6j Individual Catch Statistics

On average, over the duration of the survey, diarists who reported fishing spent 1.8 hours fishing for rock lobster and caught 0.8 lobster. The average catch rate for a diarist was 0.72 lobster/hour (Figure 21). In the Eastern Zone, on average diarists fished for lobster for 1.9 hours and caught 0.7 lobsters for a catch rate of 0.49 over the duration of the survey. In the Western Zone, on average diarists fished for lobster for 1.7 hours and caught 1.1 lobster for a catch rate of 1.1 over the duration of the study. In comparison, the data reported to VicRLTag for the same diarists only had 17% of data coverage (i.e., 17% of fishing events had effort reported) for effort (hours) that was spent fishing for rock lobster by diary survey participants and was likely underestimated at 0.5 hours. The average catch of diary survey participants reported to VicRLTag was 1.46 lobster. The average catch rate of diary survey participants using VicRLTag data was 11.03 lobster/hour, which was influenced by the low reporting rate for effort, high variability in fishing time reported (from hours to mere seconds), and that only successful fishing trips were reported. Whereas, in the diary survey fishing effort was clearly reported with start and end times by the majority of participants who fished for rock lobster and the data contained zero catch fishing trips that will result in a more realistic CPUE calculation.

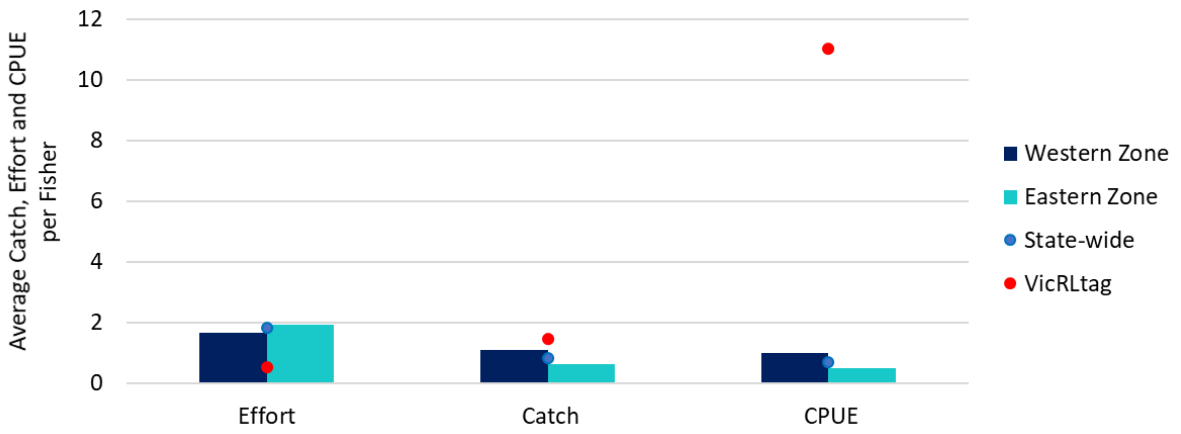


Figure 21 *The average effort (hours), catch and CPUE (catch/hour) for a diarist and the average effort, catch and CPUE for the same diarists as reported to VicRLTag for the study period.*

6.2.6k Multiple Target Species

Although most of the reported fishing effort was targeted exclusively at rock lobster (324 events or 69% of the total), diarists also reported targeting other species, including abalone and/or scalefish, when searching for rock lobster. Abalone, along with lobster were targeted or caught on 146 dive events (31.1% of the total), while other species were targeted or caught on 42 rock lobster trips targeting (8.9%). Diarists reported 69.9% of effort (569.22 hours) allocated exclusively to targeting rock lobster, 21.8% to targeting rock lobster and abalone and 7.8% to targeting rock lobster and other species. Diarists who indicated that they were exclusively targeting rock lobster caught the most rock lobster, obtaining 320 individuals or 80.1% of reported catch, followed by 13.4% of the catch when targeting both rock lobster and abalone, and 5.8% when targeting other species along with rock lobster.

Although the majority of catch and effort of other species were harvested by fishers targeting both rock lobster and other species, some diarists that were targeting rock lobster exclusively or rock lobster and abalone on a fishing trip also (opportunistically) harvested scalefish. Fishers who reported only fishing for rock lobster also harvested 11 individuals of other species, primarily Velvet Crab, sweep and Snapper (Table 4). Diarists fishing for rock lobster and abalone reported also harvesting 24 individuals of other, primarily of Magpie Morwong, leatherjackets, and sweep. Diarists that were targeted rock lobster and “other species” caught 56 individuals of other species, mainly sweep, flathead, Bluethroat Wrasse and Snapper.

In total, diarists caught 91 individuals of other species while fishing for over 134 hours during the diary survey. Rock lobster were most often caught with Bluethroat Wrasse, sweep and Snapper. While abalone were most often caught with Bluethroat Wrasse, sweep, Luderick, leatherjackets, and sea urchins.

Table 4 *Catch by nominated target species when fishing for rock lobster (RL rock lobster, AB abalone The number of rock lobster and abalone that were harvested with other species is provided. Where rock lobster and abalone catch has no value there was no fishing event, however, where there was a fishing trip a zero designates that no catch was achieved.*

Other Species Fished	RL Target	RL and AB Target	RL and Other Target
	Number Caught	Number Caught	Number Caught
Rock Lobster	320	53	23
Abalone		423	35
Australian Salmon			1
Banded Morwong	1		1
Barracouta			4
Magpie Morwong	1	6	
Bluethroat Wrasse			6
Boarfish			1
Butterfish	1		
Flathead (unspecified)			11
King George Whiting		1	1
Kingfish		1	
Leatherjacket (unspecified)		5	
Longsnout Boarfish			1
Luderick		4	1
Octopus			1
Pike (unspecified)			1
Sea Urchin (unspecified)		1	2
Snapper (unspecified)	2		6
Squid (unspecified)	1		
Sweep	2	5	14
Velvet Crab	2		2
Wrasse (unspecified)	1	1	1
Zebrafish			2

Total Effort (fishing events)	324	118	26
Total Effort (hours)	596	186	67

6.2.6l Regional Target Species

The fishing trips targeting exclusively rock lobster were primarily from the Warrnambool, Apollo Bay, Queenscliff and San Remo regions (Table 5). Fishing trips reported from diarists in the Portland and Lakes Entrance regions primarily targeted rock lobster and abalone. Fishing for rock lobster and other species only occurred in the Warrnambool, Queenscliff, and San Remo regions and consisted of <24% of fishing trips in these regions.

Table 5 *Number of fishing trips by the target species in each region.*

Region	RL	RL and Abalone	RL and Other	No Target
Portland	1	3		
Warrnambool	135	42	6	
Apollo Bay	9	4		
Queenscliff	112	33	7	
San Remo	67	29	13	
Lakes Entrance		7		1

6.2.6m Other Species Caught by Fishing Method

Snorkel was overwhelmingly the fishing method most used by diarists with 49 individuals of other species caught over 32 fishing trips that consisted of 91.75 hours of active fishing (Table 6). The species most often caught with snorkel were sweep and Snapper which were the species with the greatest fishing hours spent by snorkelers. Hookah was the second most used and successful fishing method for other species with diarists reporting 26 individuals of other species caught over 25 hours of fishing. Bluethroat Wrasse and flathead were the most caught species using hookah with each species having 6 individuals harvested over 6 and 2 hours of fishing respectively. By-catch in hoop nets was rare, but there were reports of Velvet Crabs and octopus as by-catch (Table 6).

Table 6 The harvest of other species by fishing method.

	Snorkel	Scuba	Hookah	Hoop Net
Species	**Catch**	**Catch**	**Catch**	**Catch**
Rock Lobster	123	114	117	42
Abalone	173	143	151	
Australian Salmon	1			
Banded Morwong	2			
Barracouta			4	
Magpie Morwong	5		2	
Bluethroat Wrasse			6	
Boarfish	1			
Butterfish			1	
Flathead (unspecified)	4	1	6	
King George Whiting	2			
Kingfish	1			
Leatherjacket (unspecified)	5			
Longsnout Boarfish			1	
Luderick	5			
Octopus				1
Pike (unspecified)	1			
Sea Urchin (unspecified)	1	2		
Snapper (unspecified)	6	2		
Squid (unspecified)		1		
Sweep	11	5	5	
Velvet Crab				4
Wrasse (unspecified)	2		1	
Zebrafish	2			
Total Effort (fishing events)	180	159	93	27
Total Effort (hours)	416	199	160	77

6.2.6n Abalone Harvested

Of the 469 fishing trips reported by diarists, abalone were targeted or opportunistically harvested on 129 (27.5%) of the trips (Figure 22). Most fishing trips (56%) resulted in 5 abalone being harvested state-wide, which was higher in the Eastern Zone (63%) than the Western Zone (48%). Zero catch fishing trips made up 23% of events reported by diarists in Victoria with 27% in the Western Zone and 16% in the Eastern Zone unsuccessful in obtaining a harvest.

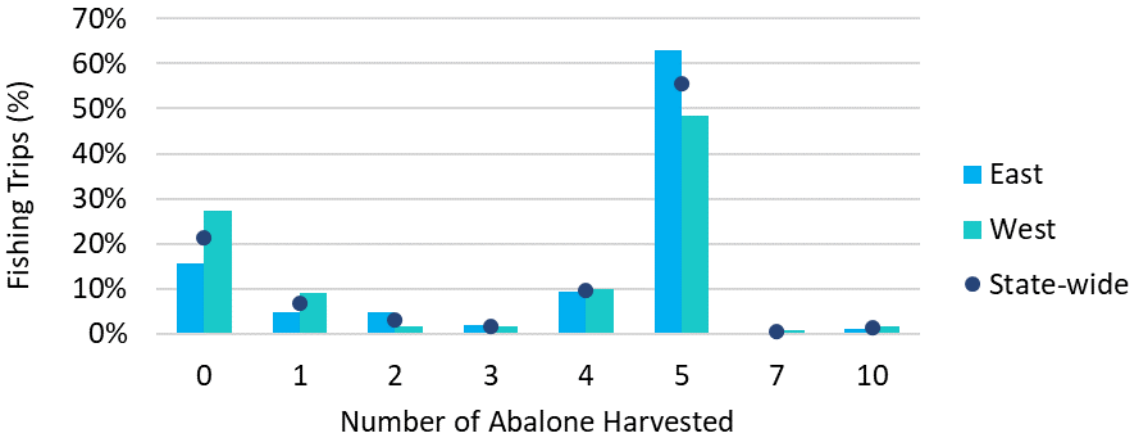


Figure 22 *The average number of abalone harvested on a fishing trip as a percentage of fishing trips taken for each region.*

Diarists reported harvesting 425 Blacklip Abalone and 42 Greenlip Abalone state-wide. The majority of harvest was from the Warrnambool (158 Blacklip Abalone and 3 Greenlip Abalone), Queenscliff (104 Blacklip Abalone and 7 Greenlip Abalone) and San Remo (112 Blacklip Abalone and 28 Greenlip Abalone) regions (Figure 23). Overall, the Eastern Zone had the majority of abalone catch with 251 Blacklip Abalone and 35 Greenlip Abalone harvested, while the Western Zone had 174 Blacklip Abalone and 7 Greenlip Abalone harvested by diarists. Blacklip Abalone were evenly caught from boat (51%) or shore (49%) based fishing, however, Greenlip Abalone was primarily caught from boat (76%) rather than shore (24%) based fishing.

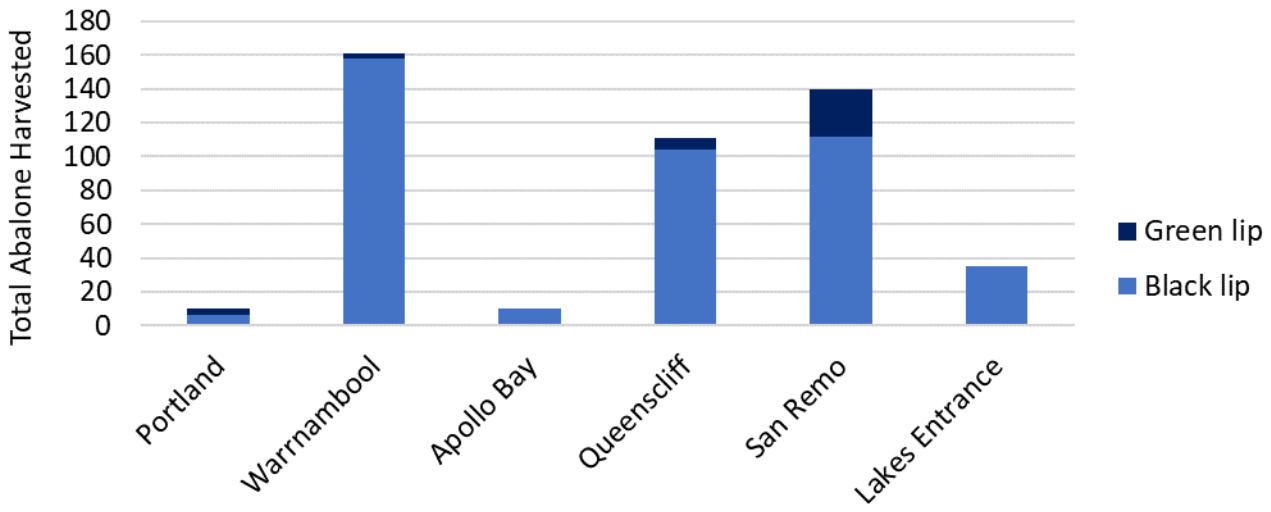


Figure 23 *The total number of Blacklip Abalone and Greenlip Abalone harvested by diarists by region.*

6.3 Wrap-up Survey

At the completion of the diary survey fully responding diarists aged 18 years and older were asked a series of questions relating to their lobster fishing activity, perceptions relating to the quality of the fishery, impacts of the COVID-19 pandemic on their fishing activities, and opinions on the management and monitoring of the rock lobster fishery.

6.3.1 Survey Sample

The wash-up survey sample were respondents who had completed the diary survey and consented to participate in the final wrap-up survey.

6.3.2 Catch Per Unit Effort (CPUE)

Slightly less than half (45%) of the diarists who fished for lobster indicated they were either quite or very satisfied with the actual catch rates (average number of lobster caught per fishing trip) they achieved during the diary period (Figure 24). Most diarists (54%) were not very or not at all satisfied with their catch rates. In relation to successful fishing trips (i.e., trips with at least one lobster caught), most respondents (52%) indicated that the proportion was about the same during the 2020/21 season when compared with the previous season, 43% suggested that success rates had declined and only 5% indicated that their success rates had increased (Figure 24).

Since the recreational lobster fishery is highly consumptive, fisher satisfaction is expected to be strongly correlated to harvest rate. To test this assumption, catch rates expressed as the total number of lobster kept divided by the total number of days fished in the diary survey were calculated for each diarist and then matched to their response to the catch rate satisfaction question. Overall fishers were generally satisfied (very or quite) with catch rates averaging over one lobster per day, whereas fishers expressed dissatisfaction with catch rates of below 0.5 lobster per day (Figure 24).

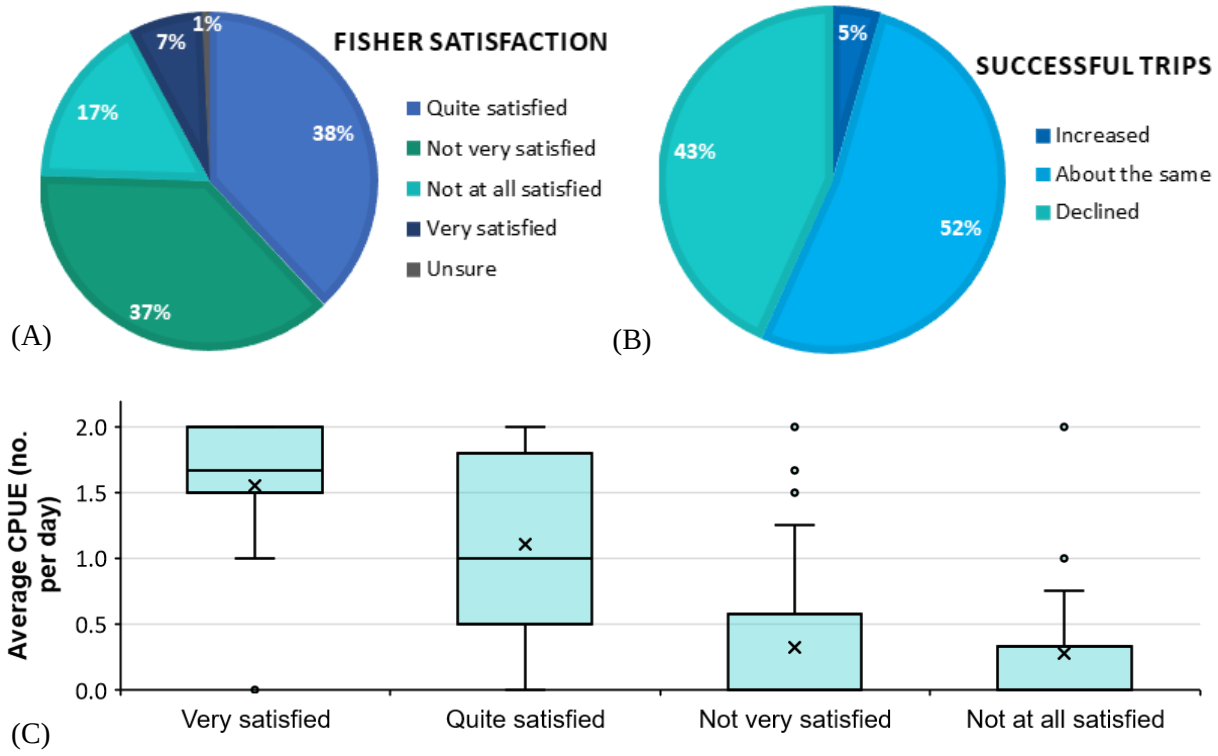
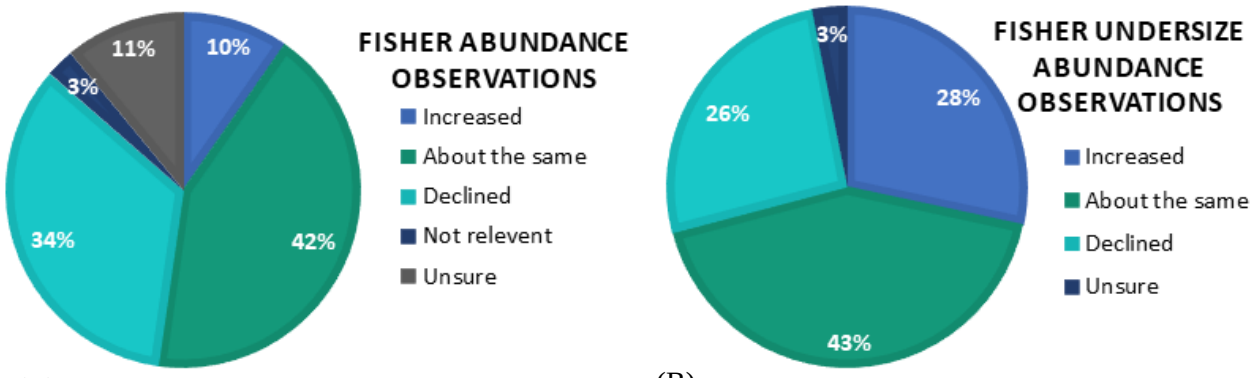


Figure 24 *The proportion of fisher satisfaction with the CPUE in the 2020/21 season (A), the proportion of successful trips undertaken by respondents in the 2020/21 season (B), and the relationship between the CPUE obtained by respondents in the diary survey and the response provided to fisher satisfaction which shows fishers with higher catch rates have an higher overall satisfaction with the program than fishers with lower catch rates (C).*

6.3.4 Lobster Abundance

Diarists who had fished for lobster during the survey period were asked to rate the relative abundance of rock lobster in 2020/21 compared with previous seasons (Figure 25). Only 10% of respondents reported observing increased abundances of legal sized lobster in 2020/21, this compared with 28% who reported an increase in the abundance of undersized lobster. By contrast, 34% of respondents reported a decline in legal sized abundance while 26% observed a decline in undersized abundance. There was no difference in the proportion of respondents (42-43%) who suggested that legal or undersized abundances was about the same in 2020/21 as in previous seasons (Figure 25).



(A) (B)

Figure 25 *The abundance changes in the 2020/21 season compared to the previous season that respondents have observed (A), and the change in the abundance of undersized lobster in the 2020/21 season to the previous season that respondents have observed (B).*

6.3.5 Constraints to Fishing

Diarists who did not report fishing for lobster were asked, as an open-ended question, about their main reasons for not fishing during the season. The primary constraints cited by respondents was lack of time due to work and/or family commitments (64%), inclement weather (34%) and the impact of COVID-19 (16%) (Figure 26).

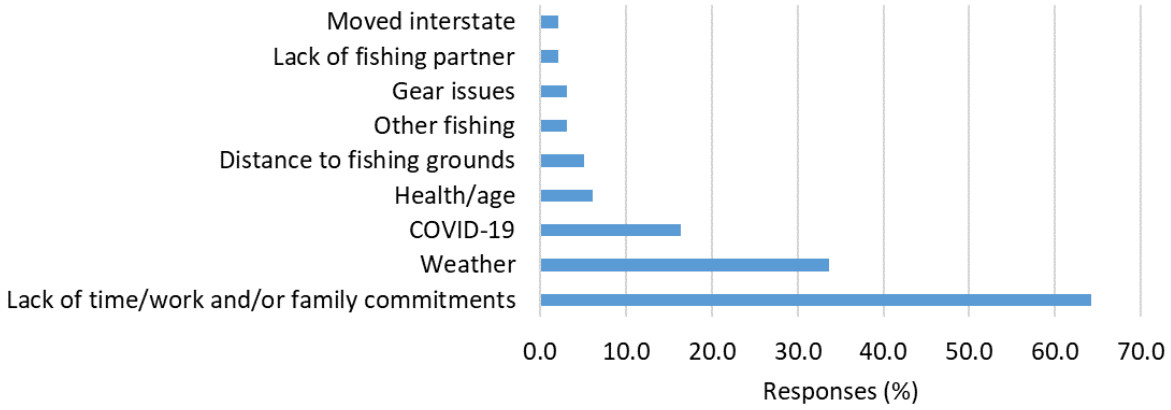


Figure 26 *The constraints to fishing in the 2020/21 season that impacted on respondents as a percentage of total responses.*

6.3.6 Covid-19

Just as the impact of the COVID-19 pandemic on the 2019/20 season was assessed in the initial survey, the wash-up survey provided an opportunity to assess the on-going impacts of COVID-19 on fishing during the 2020/21 season (Figure 27). As a result of the COVID situation the recreational fishery was closed between

the 13st and 18th February 2021. During the February 2021 lockdown 22% of respondents reported cancelling planned fishing trips, while 44% of respondents cancelled fishing trips due to COVID restrictions at other times. Respondents were also asked in what ways the Covid-19 pandemic has influenced their fishing. The impact of COVID-19 on fishing was primarily through reduced fishing activity (66%), with general travel restrictions (44%), lockdown restrictions (8%) and restrictions on fishing partners (7%) also cited as consequences of the pandemic on fishing activity (Figure 27).

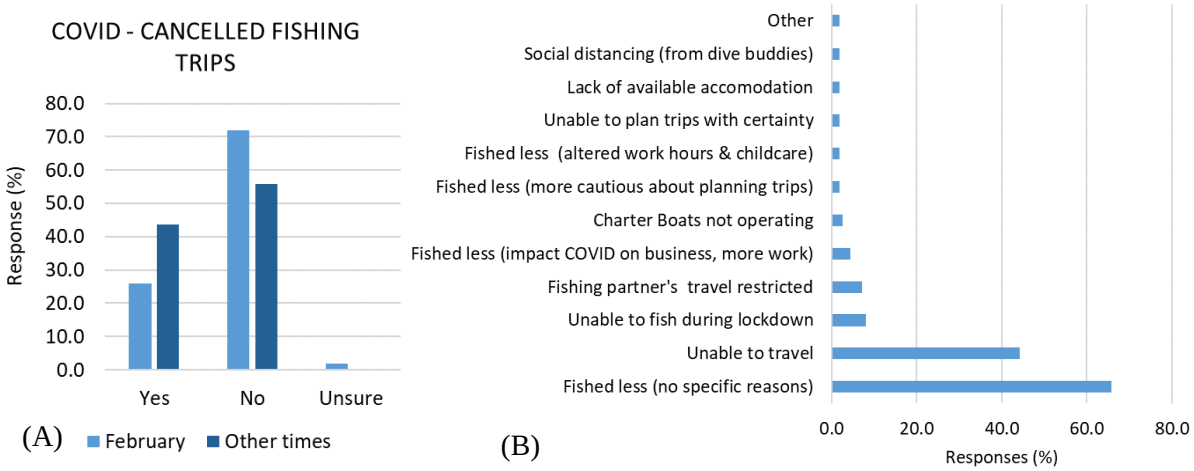


Figure 27 *The percentage of cancelled trips because of the COVID-19 pandemic (A), and the reasons for not fishing during the COVID-19 pandemic (B).*

6.3.7 Compliance Checks

Of the diarist who reported catching rock lobster, only 12% had compliance checks conducted on their catch. Most of the respondents who caught rock lobster had not had a compliance check-up during the survey period (88%) (Figure 28).

6.3.7a Carapace Length (CL) Measurements

All recreational fishers in Victorian waters are required to ensure the CL of retained lobster is above the minimum legal-size limit. Respondents were asked how they determined CL for reporting in the VicRLTag app, and most (81%) indicated that they used the VFA gauge, with rulers or tape measures (14%) and callipers and other gauges being alternative approaches used by respondents (Figure 28). The VFA gauge used by the majority of respondents is designed to determine if a lobster is above the minimum legal-size limit but not measure the specific length of the lobster. About 5% of respondents reported relying on estimated lengths.

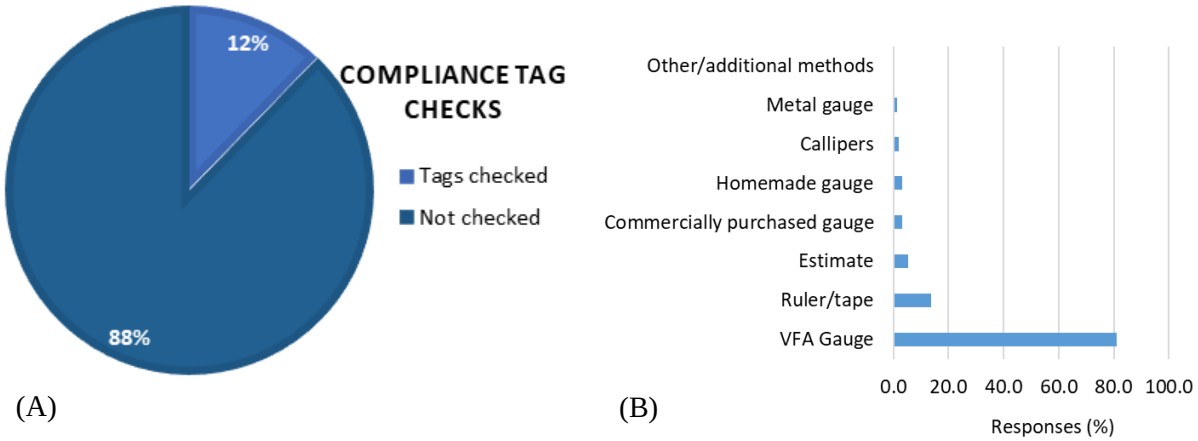


Figure 28 *The proportion of respondents that had a compliance check in the 2020/21 season (A), and the device or method used by respondents to measure the CL.*

6.3.8 Proposed Tagging Program Revisions

Respondents were advised that the current VicRLTag program was under review and that for the 2021/22 season a new reporting app will be rolled-out and that while mandatory reporting of catch will remain there will be no requirements to affix a plastic tag to the lobster.

6.3.8a Reporting Timeframe

Respondents were informed that the timing of when catch reports need to be submitted was under consideration and that the VFA was seeking feedback about preferences for reporting of catches. The highest proportion of respondents supported reporting of catches within 24 hours of capture (63%) (Figure 29). Reporting prior to leaving the place of catch landing and within 48 hours both had the least support from respondents (26.8%). Cumulative support, that is based on the least duration from time of capture that an individual respondent indicated support, suggested that 95% of respondents supported reporting catches within at least 24 hours of capture.

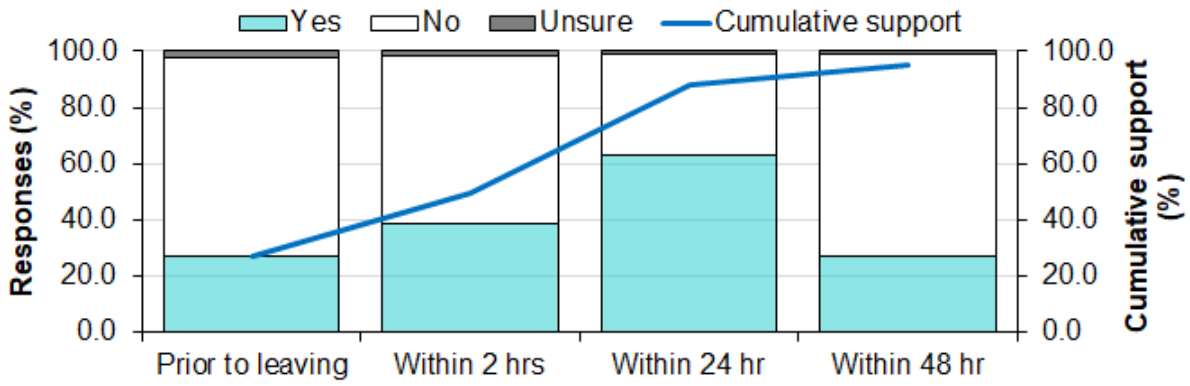


Figure 29 *The support for proposed timeframes for reporting catch in VicRLTag.*

6.3.8b Zero Catch Trip Reporting

Respondents were reminded that the current tag system requires fishers to only report on trips that result in a catch. However, including all trips, regardless of whether lobster are caught, has potential to provide a more complete picture of fishing activity and fishing success rates, as well as providing an indicator of rock lobster abundance (Figure 30). While most respondents (61%) were of the opinion that information on zero catch fishing trips was valuable for managing the Victorian recreational rock lobster fishery, only a minority (14%) were supportive of mandatory reporting of zero catch fishing trips. Most respondents (85%) were, however, supportive of voluntary reporting of zero catch fishing trips (Figure 30).

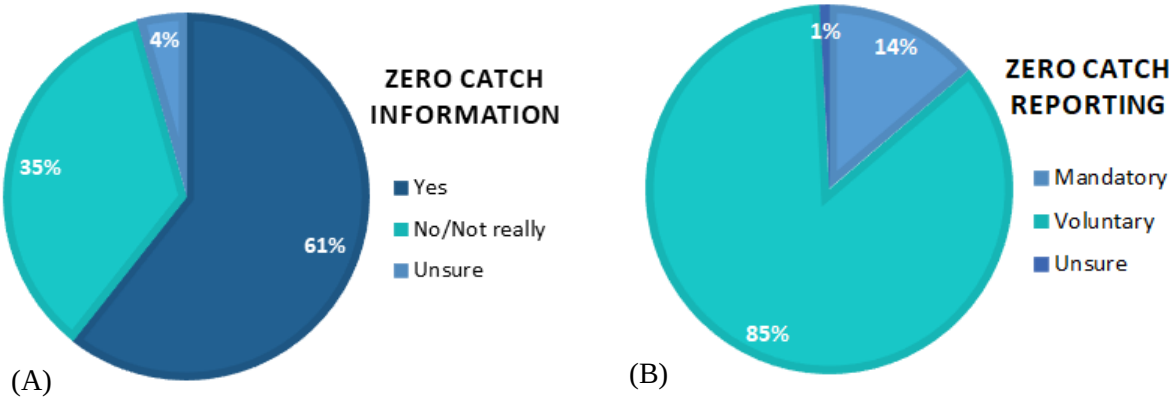


Figure 30 *The proportion of respondents that perceive a benefit from collecting information on zero catch fishing trips (A), and the proportion of respondents that would like zero catch reporting to be voluntary or mandatory in VicRLTag (B).*

6.3.8c Fisher Incentives

Respondents were informed that another component of the new reporting system will be a voluntary option to provide additional fishing information, such as location fished, methods used, time spent fishing, weight and sex of any lobster caught, comparable to the "citizen science" option in the current tag

reporting app. Respondents were presented with a number of incentives and asked which, if any, they thought would make this additional reporting option appealing enough to consider signing up for it in the future.

Regular updates on fishery-wide catch and effort information attracted support from the greatest number of respondents (73%), emphasising the importance of two-way communication and feedback to fishers and highlighting the importance and benefits of the data being provided (Figure 31). Give-aways and the provision of a balance or callipers to measurelobster were also identified as appealing to most respondents (66% and 62%, respectively). The inclusion of networking options for sharing of information with friendship groups was the least appealing incentive to respondents (34%). Additional app features (e.g., access to weather or sea condition reports) and personal statistics appealed to 56% and 49% of respondents. Collectively, these responses suggest that the focus of the new app should be on catch reporting rather than non-essential features that may have limited uptake.

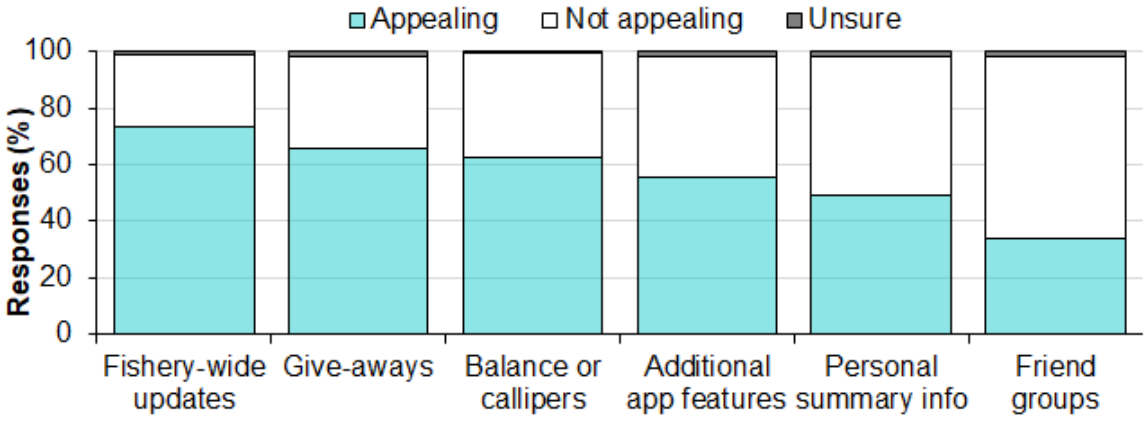


Figure 31 *The support for incentives to encourage participation in the electronic catch reporting program.*

6.3.8 Preferred Reporting Approach

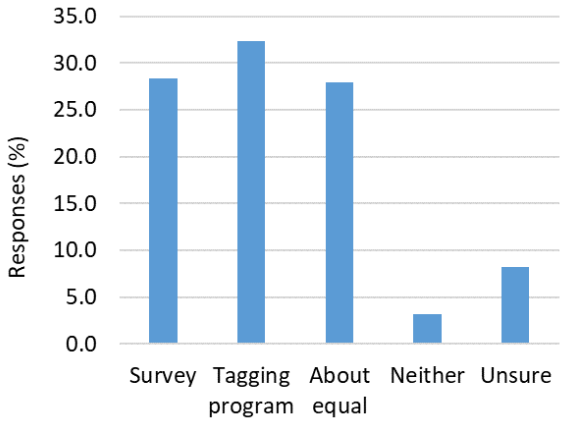


Figure 32 *The preferred catch reporting method of respondents.*

Finally, respondents were asked to consider their involvement in the phone-diary survey and experiences with the current VFA tagging program, in terms of the approach they considered to provide a more accurate representation of recreational catch and effort in the rock lobster fishery. While slightly more respondents indicated they considered the tagging program to be more accurate (32% compared with 28% for the diary survey), a similar proportion of respondents (28%) indicated that both approaches were equally reliable (Figure 32). Only 3% of respondents considered neither approach to be reliable, with a small number of respondents unsure (8%).

Respondents who indicated a preference for the survey approach identified that it provided more in-depth information (52%), being voluntary the information is likely to be reported more accurately (22%) and engagement from interviewers was positive and encouraging. The primary reasons for support of the tagging program were that it is mandatory (22%), data are likely to be comprehensive and accurate (15%), and reporting via the app and use of tags are easier than the survey approach (14%) (Table 7).

Table 7 *The reasons respondents preferred the diary survey or electronic catch reporting (VicRLTag) method for reporting recreational catch.*

Survey Preferred Reasons	**Responses (%)**
Survey provides more in-depth information	52
Data likely to be reported more accurately	22
Engagement by interviewers is positive and encourages reporting	17
Survey easier than tags and app reporting	3
Other	6
Electronic Tag Reporting Preferred Reasons	
Reporting is mandatory, so everyone is required to report	22
Data likely to be more comprehensive and accurate	15

App and tags easier than survey	14
Assume most people comply with tag system	10
Survey uptake nonresponse	7
Data reported in real time	8
Tag system is tried and accepted	4
Survey provides complementary information	3
Other	18

7. Conclusions and Recommendations

The current VicRLTag has had good uptake by recreational fishers with over 5000 accounts, however, only 24% of participants reported tag usage in 2018/19 (noting that an unknown proportion of the remaining 76% will genuinely not have fished). Implementing app features that increase participation of fishers in the program and the reporting rate, such as the incentives provided in green in Table 1, could be considered. From the information provided by recreational catch reporting programs operating internationally that we contacted, the success of these incentives is reliant on understanding the demographics of participants in the fishery and the motivations of fishers. Features that incentivise participants to report on data limited variables in VicRLTag, such as fishing time, fishing method (gear) and lobster sex, should be considered. However, priority should be given to improving data accuracy, particularly for variables directly related to the core objectives of the program (e.g., catch and effort), in the revised VicRLTag app. Reported active fishing time and weights have high variability and may require clarification though a variable definition and defined unit of measure. The compulsory linking of licence numbers with account details can assist in account verification and tracking participation over time.

7.1 Recreational Catch reporting

Key learnings from the fisher surveys that could be considered to improve VicRLTag include:

- The primary method for fishers to determine CL is by gauge. An increase in the use of callipers to provide a measure the CL and accurately report would improve the accuracy of length data reported.
- Comparing the fisher surveys with VicRLTag reports detected minor inconsistencies. Both fisher surveys and VicRLTag data are subject to biases and inaccuracies including misreporting and recall error. The comparison detected a small proportion of fishers in both the initial survey and diary

survey that did not report catch accurately to VicRLTag. However, the vast majority of fishers had reported catch consistently in both the fisher surveys and VicRLTag.

- Potential misreporting was also detected in the fisher surveys when participants harvested species that were not the target species. It is unclear if this was opportunistic catch or misreporting of the species being targeting during the fishing event. However, as target species could be included as a reporting parameter in the revised VicRLTag app, this misreporting may also become present in VicRLTag data.
- The CPUE in VicRLTag is substantially higher than the CPUE calculated in the diary survey and regional variability in CPUE may be masked by the lack of reporting of zero catch fishing trips in VicRLTag compared to the survey data.
- The majority of recreational fishers surveyed support a reduced reporting timeframe from the end of the season to within 24 hours.
- Incentives, such as fishery wide updates, giveaways, and the provision of callipers, were of interest to recreational fishers surveyed.

7.2 Database Configuration

The current storage of data collected in the VicRLTag program and secure access to databases containing user and catch data by managers and project leaders at the VFA could be improved. Integration of the database holding the VicRLTag account holders' details and database with the reported tag information is recommended. Compliance officers have access to the information on reported tags. Secure access to download the data on demand should be provided to VFA, who can then deliver it to the researcher provider (IMAS) in a timely manner. Consistency in data download formats and management of the data by VFA would be beneficial to allow direct download of the data by VFA. Currently, each time the data changes, additional work to alter the analysis scripts is required, introducing the possibility of errors. Management of the data by VFA would enable analyses to be streamlined and more readily available to support decision-making on short timeframes as required. Capabilities for basic analyses of the data and regular summaries should also be available to managers and program leaders at VFA.

The current method for integrating the account data on registered users, which is held in one database, with data on tags issued and reported, which is held in a sperate database, is the use of an email address. Further unique identifiers for linking account holders with the tags that have been issued should be developed, such as recreational fishing licence number, name or address. In the current system, in theory, a participant could create a new account using a new email address each season and avoid reporting tags before having the next

seasons tags issues. Unique identifiers would also allow researchers to track participant retention and catch history more effectively.

7.3 Additional App Features

The additional features that could be incorporated into VicRLTag, outlined in Table 1, are prioritized in Table 8. High priority items that are recommended to be considered for inclusion in VicRLTag directly relate to management objectives. Low priority features are recommended as optional additions that are related to improving user experience and incentivising participation, which aim to increase data accuracy and on-going participant engagement. Features that are not recommended have no substantial benefit to management objectives nor do they improve user experience and may, in some cases, be expensive to implement. Methods for automatically calculating biological characteristics, such as the length of a lobster, are appealing. However, there will be tremendous variability in the conditions in which lobsters are photographed for measurements to be obtained and a broad diversity of smart phones used. This variability is likely to result in inaccurate measurements that are of limited scientific use. Furthermore, this is likely to be one of the more expensive additional features to implement. These emerging app features are generally allocated a level 4 priority where these features may be worth considering in the future, but at the current stage of development do not make an improved contribution to management objectives or data accuracy of the VicRLTag program.

Table 8 *The potential cost to enact features defined in Table 1 that could be integrated into VicRLTag and a recommendation (yes, no, or optional) for implementing the feature. Each feature is given a priority classification where: 1. High priority, 2. Low priority, 3. Not recommended, and 4. Not currently recommended but could be reassessed in the future.*

New Features	Potential Enactment Cost	Recommended	Priority
Digital Tags	LOW	Yes	1
Geolocation	LOW	Yes	1
Offline reporting	LOW	Yes	1
Trip Log/ pre-registering an intention to fish	LOW	Yes	1
Automatically Time/Date -stamped	LOW	Yes	1
Photo upload with geolocation	LOW-MEDIUM	Optional	2
Rock Lobster Information	LOW	Optional	2
Management information (current rules and regulations)	LOW	Optional	2
Personal Log (Diary) of reported Catch/Effort	LOW-MEDIUM	Optional	2

A digital wallet for storing licences and fishing documents	LOW	Optional	2
Save fishing locations on map	LOW	Optional	2
Comparison of personal log/ statistics	LOW	Optional	2
Multi-platform compatibility	HIGH*	Optional	2
Photo upload (optional)	LOW-MEDIUM	No	3
Solar/ Lunar/ Tide/ Weather Guides	MEDIUM	No	3
Route/trip tracking and planning	LOW-MEDIUM	No	3
Weight estimates from phone	HIGH	No	3
Ruler for carapace length	HIGH	No	4
Photo upload for algorithms to determine lobster features (e.g., length, gender)	HIGH	No	4
Export information	LOW	Optional	2

*Dependent on if the platforms are stand-alone or integrated.

7.4 Additional Data Collection

The collection of additional data variables, which are defined in Table 2, into the VicRLTag app are prioritised in Table 9. High priority data variables that are recommended to be considered for including into VicRLTag directly relate to management objectives. Low priority data variables are recommended as optional additions that are related to additional background information collected to improve a contextual understanding of the fishery. These low priority data variables are primarily directed at citizen scientists who opt-in to provide additional information to complement catch reports. There are two data variables that are not recommended as they do not add to the objectives of the program, which is to obtain catch data and estimate catch rate, or provide useful information on the fishery. At the request of VFA, an abundance index is to be included in the revised VicRLTag program. Our recommendation for this is in the appendix.

Table 9 *Recommendations for expanding the information collected by participants and citizen scientists. The definition of each variable is provided in Table 2. Each variable proposed is given a priority classification where: 1. High priority, 2. Low priority, and 3. Not recommended.*

Variable	Recommended	Priority	All Users or Citizen Scientist
Fisher's fishing experience	Yes	1	All Users
Target species	Yes	1	All Users
Fishing platform	Yes	1	All Users
Unsuccessful fishing trip	Yes	1	All Users
Fisher gender	Optional	2	All Users
Fisher preferences	Optional	2	All Users
Fisher memberships of fishing clubs	Optional	2	All Users
Trip duration	Optional	2	Citizen Scientists

Fishing start and end time	Optional	2	Citizen Scientists
Fishing depth	Optional	2	Citizen Scientists
Fishing party	Optional	2	Citizen Scientists
Catch reporting by proxy	Optional	2	All Users
Species and number caught	Optional	2	Citizen Scientists
Spawning status	Optional	2	Citizen Scientists
FAQ page	Optional	2	All Users
Fisher nationality	No	3	All Users
Abundance Index	No	3	Citizen Scientists

7.5 Implementation

The implementation strategies and global perspectives of several mandatory and voluntary recreational catch reporting programs are discussed in detail in the 'Implementation of catch reporting apps' section of this review. Based on the successful strategies applied by these other programs, we make the following recommendations:

1. Key variables should be identified, and fishers encouraged to prioritise reporting of these key catch and effort variables. Prioritising a small number of key variables (around 5–9) will promote an increase the raw number of data point informing the catch rate estimates and reduce the time required of fishers to submit a report by focusing their effort on the most important aspects. Factors that are not identified as key (i.e., information that is desirable but not essential and can have lower reporting rates) should be moved into the voluntary citizen science component of the program or made voluntary for all users. Ideally, variables about catch, effort and catch rate should be compulsory reporting fields for all fishers as they address the key management objectives, while biological and operational variables that complement the core information being provided should be in the citizen science component.
2. A simplistic app design and structure that focuses on the needs of the core audience and functionally supports reporting catch which is the main purpose of the app. Avoid gamification trends and elaborate features that may not be utilised by the core audience and may distract from or undermine the core objective of catch reporting. Syncing between reporting platforms is desirable if the infrastructure is in place to support it without slowing the app and impairing user experience.
3. Compliance regulations should be enforceable in a mandatory program and encourage increased catch reporting rates, such as the requirement to report at place of landing. A trip log (hail in/out) is a viable option to replacing plastic tags in VicRLTag program while allowing for compliance checks to take place at point of landing or prior to landing. The compliance rates of mandatory programs were higher than voluntary programs showing that well-developed compliance regulations can increase catch reporting rates. Without well-developed compliance regulations that promote catch reporting

the VicRLTag program would in practice be voluntary and obtaining a measure of the non-compliance rate (specifically the data that is missing/not reported) would be important to interpret and improve catch rate estimates obtained from the app.

4. Validation of the data obtained in VicRLTag is important to understand compliance rates and improve catch rate estimates. All the programs we communicated with have a data validation process in place. A plan for establishing data validation in the VicRLTag program would measure compliance rate and data accuracy that can build support and increase the confidence of stakeholders in the program. Beckman et al. (2019) outline methods of data collection in recreational fisheries such as dock-side surveys that can be used to validate electronic catch reports.
5. Ready availability of technical support, particularly during the initial release of the revised VicRLTag app, would resolve bugs and user issues before fishers are deterred from using the app. Collecting metrics of app usage could be a useful method of identifying technical issues and aspects of the app that fishers do not engage with.
6. A data analysis and dissemination plan including a data policy that is communicated to stakeholders has been a successful approach in the other programs to build confidence and trust in the program that encourages increased participation which could be applied to VicRLTag. Stakeholder awareness of how the data will be used, where they can access data analyses and what feedback they can anticipate could encourage fishers to support providing data to the program such as fine-scale spatial data.
7. Communication strategies to educate, promote and encourage stakeholder participation in the program forms a core part of the electronic catch reporting programs around the world we held discussions with. The development of communication strategies for the VicRLTag app that can continually motivate and incentivise participation and the retention of participants over time can support the success of the program. Through providing meaningful feedback on information program leaders can decrease the rate of non-reporting and promote user uptake and retention among fishers.

When considering which new features and variables to implement into VicRLTag trade-offs between the benefits, limitations, the cost of implementing the features and the utility within the VicRLTag app need to be made. Therefore, not all options and priority items will necessarily be required to be implemented to improve the program and VicRLTag app. However, focus should be given to the implementation of features and variables that are directly related to management objectives and improve data accuracy.

8. Outcomes

In the 2021/22 season the VFA launched a revised recreational rock lobster catch reporting app to replace VicRLTag. Information provided in this report, along with the steering committee meeting feedback over 12 months of consultation, were considered when developing the new app. Below we outline the changes that were implemented by the VFA in the new recreational rock lobster catch reporting app.

8.1 App Platform and Features

Recreational rock lobster reporting has been integrated into the GoFishVic app and the VicRLTag app has been discontinued from the commencement of the 2021/21 season. As a result of this app integration, recreational fishers in Victoria have a single electronic catch reporting app across all species rather than a rock lobster specific app. A key benefit of integrating the platforms is that many of the features that a revised VicRLTag app could have benefited from where already built into the GoFishVic app.

Additional features that are accessible to fishers in the revised GoFishVic include:

- Ability to add catch photos and maintain a record of catch history.
- Social media integration allows fishers to share trip and catch details with friends and fishing groups.
- Availability of personal catch statistics based on catch reports are available to fishers.
- Fishers who sign up to provide additional information through the citizen science component of GoFishVic will also have access to a more detailed 'lobster season diary'.
- Ability to receive the latest news from the VFA via the 'newsfeed' functionality.
- Access to club functionality where users can create and join fishing clubs and events
- Weather information will be available within the app for fishers to plan their trip.

In addition, a stand-alone lobster reporting web portal has been developed to assist all users (regardless of access to a smart phone) complete their mandatory reporting requirements. The web portal mirrors the GoFishVic lobster reporting section and is accessible via the VFA webpage https://gofishvic.vfa.vic.gov.au/user/auth/login.

8.2 Catch Reporting

The new GoFishVic app has a voluntary set-and-forget trip reporting that allows fishers to start a trip prior to departure (hail-in) and close a trip on conclusion (hail-out). However, there is no mandatory requirement that fishers use the trip reporting prior to a fishing trip, the requirement of fishers is that the trip information be reported within 7 days of the catch being obtained. The requirement to start and finish a trip for all catch reports provides a 'trip duration' from which catch per unit of effort can be calculated. To further improve this accuracy, citizen scientists provide additional detail on the total time spent targeting rock lobster.

Recreational fishers can now voluntarily report fishing trips with zero catch in GoFishVic. Previously in VicRLTag, only catch obtained on successful fishing trips were reported by fishers resulting in inflated CPUE estimates. In addition, recreational fishers can voluntarily report the targeting of multiple species, not just rock lobster, during a fishing trip in GoFishVic. While the reporting of the sex of rock lobster caught was previously voluntary, in the new GoFishVic app it is mandatory for recreational fishers to report the sex of lobster harvested. The sex information collected will be used to convert sex-based length measurements into weight to get a more robust estimate of weight taken by the recreational section than the lobster weights provided by fishers.

Fishers are required to report their trip type (boat or shore) and fishing method (freedive, hoop net, scuba or hookah). Mandatory fishing method reporting will further strengthen the ability to analyse catch per unit of effort and consequently improve the robustness of this performance indicator to inform management.

In addition, voluntary opt-in citizen scientists can also report on the number of rock lobster observed (and not caught) during a trip in the abundance index field. The addition of this information seeks to formalise anecdotal observations of abundance from which long-term trends can be compared with other stock abundance indicators.

8.3 Compliance and Non-reporting

At time of launching the app, recreational fishers were given seven days to report catch in the electronic catch reporting app prior to an infringement notice being issued by compliance officers. This is a reduction in the reporting time available to recreational fishers to report catch from previous seasons under the

VicRLTag app, where fishers had until the end of the season to report. The reduction in reporting time aims to improve the ability for Fisheries Officers to complete follow-up action where-by they can now determine compliance within 7 days rather than waiting until the end of the season.

8.4 Communication

Education of the new program requirements was the initial focus as the new GoFishVic app was rolled out. Online community forums were held by the VFA to guide fishers through the new reporting platform. An extensive communication and social media campaign, including a new promotional video and dedicated webpage, was developed by the VFA to coincide with the launch of the recreational rock lobster reporting in GoFishVic app.

As part of the GoFishVic app, news and insights from VFA are provided to fishers in the Fish 'n' Tips section of the app. This communication feature of the app provides further feedback to fishers and creates two-directional communication.

Incentivisation to report rock lobster catch in the revised GoFishVic app is further enhanced by the production and distribution of a measuring device for recreational fishers from VFA. This measuring device is designed specifically for accurately measuring rock lobster with consideration of the curve of the carapace taken into consideration. The provision of this measuring device to recreational fishers aims to increase the accuracy and robustness of data reported in the app rather than fishers estimating carapace length from a gauge.

9. References

Beckmann, C., Tracey, S., Murphy, J., Moore, A., Cleary, B. and Steer, M. (2019). Assessing new technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys. https://pir.sa.gov.au/__data/assets/pdf_file/0007/342772/Assessing_new_technologies_and_techniques_that_could_improve_the_cost-effectiveness_and_robustness_of_recreational_fishing_surveys.pdf

Brick, J.M. (2018). Electronic Reporting in Survey Research Applied to Estimating Fishing Effort. https://www.fisheries.noaa.gov/webdam/download/87828513.

Bradley, D, Merrifield, M, Miller, KM, Lomonico, S, Wilson, JR, Gleason, MG. (2019). Opportunities to improve fisheries management through innovative technology and advanced data systems. *Fish and Fisheries*. 20: 564– 583. 10.1111/faf.12361.

Collier, C., Dick, K. and Fitzgerald, B. (2019). MyFishCount Completion Report: A pilot project on electronic reporting for private recreational fishermen in the South Atlantic region. https://safmc.net/download/Briefing%20Book%20Council%20Mtg%20Sep%202019/TAB%2010%20-%20Full%20Council/TAB10_A2a_MyFishCountFinalReportv6.pdf

European Commission (2020) Control scheme for recreational catches of sea bass: Final Report, ISBN 978-92-76-26306-7 doi:10.2771/154784.

Fujita, R., Cusack, C., Karasik, R., Takade-Heumacher, H. and Baker, C. (2018). Technologies for Improving Fisheries Monitoring. Environmental Defense Fund, San Francisco. 71 pages.

Gundelund, C., Arlinghaus, R., Baktoft, H., Hyder, K., Venturelli, P. and Skov, C. (2020). Insights into the users of a citizen science platform for collecting recreational fisheries data, *Fisheries Research*, 229. 10.1016/j.fishres.2020.105597.

Gutowsky, L.F.G., Gobin, J., Burnett, N.J., Chapman, J.M., Stoot, L.J. and Bliss, S. (2013), Smartphones and Digital Tablets: Emerging Tools for Fisheries Professionals. *Fisheries*, 38: 455-461. 10.1080/03632415.2013.838133.

Hancock, H. (2012). In *There's an app for that: using apps for scientific data collection*, Fisheries Information and Technology Section.

Hartill, B., and Thompson, F. (2016). Review of self-reporting tools for recreational fishers. New Zealand Fisheries Assessment Report 2016/06. https://fs.fish.govt.nz/Page.aspx?pk=113&dk=23998

Jiorle, R.P., Ahrens, R.N.M. and Allen, M.S. (2016), Assessing the Utility of a Smartphone App for Recreational Fishery Catch Data. Fisheries, 41: 758-766. 10.1080/03632415.2016.1249709.

Lyle et al. (2019). 2017/18 survey of recreational fishing in Tasmania, https://dpipwe.tas.gov.au/Documents/TAS_recsurvey-1718_FINAL.pdf.

McCormick, J.L., Quist, M.C. and Schill, D.J. (2013) Self-Reporting Bias in Chinook Salmon Sport Fisheries in Idaho: Implications for Roving Creel Surveys, *North American Journal of Fisheries Management*, 33:4, 723-731, 10.1080/02755947.2013.808293.

NOAA (2019). Marine Recreational Information Program, Research and Evaluation Team Review of the iAngler and iSnapper Reporting Programs. https://www.fisheries.noaa.gov/webdam/download/97231493

Papenfuss, J.T., Phelps, N., Fulton, D. and Venturelli, P.A. (2015), Smartphones Reveal Angler Behavior: A Case Study of a Popular Mobile Fishing Application in Alberta, Canada. *Fisheries*, 40: 318-327. 10.1080/03632415.2015.1049693.

Stunz, G.W., Johnson, M., Yoskowitz, D., Robillard, M. and Wetz, J. (2014). iSnapper: design, testing and analysis of iphone-based application as an electronic logbook in the for-hire Gulf of Mexico red snapper fishery. https://grunt.sefsc.noaa.gov/P_QryLDS/download/CR954_Stunz_2014.pdf?id=LDS.

Skov, C., Hyder, K., Gundelund, C., Ahvonen, A., Baudrier, J., Borch, T., deCarvalho, S., Erzini, K., Ferter, K., Grati, F., van derHammen, T., Hinriksson, J., Houtman, R., Kagervall, A., Kapiris, K., Karlsson, M., Lejk, A. M., Lyle, J. M., Martinez-Escauriaza, R., Moilanen, P., Mugerza, E., Olesen, H. J., Papadopoulos, A., Pita, P.,

Pontes, J., Radford, Z., Radtke, K., Rangel, M., Sagué, O., Sande, H. A., Strehlow, H. A., Tutiņš, R., Veiga, P., Verleye, T., Vølstad, J. H., Watson, J. W., Weltersbach, M. S., Ustups, D., Venturelli, P. A. (2020). Expert opinion on using angler Smartphone apps to inform marine fisheries management: status, prospects, and needs, *ICES Journal of Marine Science*, , fsaa243, https://doi.org/10.1093/icesjms/fsaa243

Turner, R. A., N. V. C. Polunin, and S. M. Stead. (2014). Social networks and fisher's behavior: exploring the links between information flow and fishing success in the Northumberland lobster fishery. *Ecology and Society* 19(2): 38. 10.5751/ES-06456-190238.

van der Hammen, T., de Graaf, M. and Lyle, J. M. (2015). Estimating catches of marine and freshwater recreational fisheries in the Netherlands using an online panel survey. *ICES Journal of Marine Science*, 73: 441–450.

Venturelli, Paul & Hyder, K. and Skov, C. (2016). Angler apps as a source of recreational fisheries data: Opportunities, challenges and proposed standards. *Fish and Fisheries*. 10.1111/faf.12189.

VFA (2020) Victorian Recreational Rock Lobster Tagging Program Summary Report. Victorian Fisheries Authority Report Series No.12.

10. Extension and Adoption

The current project has been disseminated to resource managers, industry and the broader public in the following ways:

- The Recreational Rock Lobster Tagging Program Steering Committee met 13 times between August 2020 and August 2021. While updates on the project were provided by Karlie McDonald and Toby Jeavons to fishers at every meeting, there were seven formal presentations on the project given in September 2020, October 2020, January 2021, March 2021, May 2021, July 2021 and August 2021.
- The Victorian Rock Lobster RAG met quarterly for the duration of the project and were updated on the project by Toby Jeavons, Klaas Hartmann and Karlie McDonald.
- Port visits to five major fishing centres along the Victorian coastline in February 2021 were conducted by Toby Jeavons, Klaas Hartmann and Karlie McDonald at which industry and commercial fishers were made aware of the project.
- Fisher survey summaries were developed by the authors and distributed to all registered Victorian recreational rock lobster fishers by the VFA. The documents are also available to the broader community on the VFA website.

Project coverage

Gio Braidotti (unpublished) 'Keen amateurs prove a major force in scientific discovery', FRDC FISH Magazine.

Appendices

Appendix 1: Project Staff

University of Tasmania
Institute for Marine and Antarctic Studies
Dr Karlie McDonald
Assoc Prof Jeremy Lyle
Dr Klaas Hartmann
Mrs Fiona Ewing
Ms Shirley Lines
Ms Josephine French

Victorian Fisheries Authority (VFA)
Mr Toby Jeavons

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.

Appendix 3: Interview Notes

iSnapper (Texas, USA)

Program	**Contact Name**	**Affiliation**	**Date of interview**
iSnapper	Tara Topping	Harte Research Institute, Texas A & M Corpus Christi	9/2/21

General Comments

- The iSnapper program for the Texas recreational snapper fishery started in 2015 as a federally funded program. The start-up costs for iSnapper were ~$100 000. In addition, an on-going annual cost of ~$100 000 including data analysis was anticipated to maintain the program. The iSnapper program was not funded in 2021.
- There have been substantial ongoing maintenance costs, such as hours of testing and debugging of the app and a lot of time spent on data analysis on a continuous basis, required to maintain the benefits of the program. As demonstrated from the annual costs ~$100 000, electronic catch reporting programs have on-going maintenance, such as data analysis, validation surveys and app updates.

- An iSnapper administrator account has the functionality to download all trip data, obtain a weekly summary of trips, and have direct access to the database data at any time. The current VFA administrator account for the database could be expanded so that managers can access and download the data at any time and conduct simple data exploration or analysis.
- The Mississippi tails 'n' scales program (discussed later in the section) is considered the "gold standard" of recreational catch reporting programs in the Gulf of Mexico. However, it should be noted that Mississippi has a unique system and coastline – small coastline with few launching locations (~3 public boat ramps). A similar successful program Snapper Check in Alabama, which is also discussed in detail in this report, has 15-20 access points from the coast. Compared to both Mississippi and Alabama, Texas has a larger coastline with a greater number of public and private access points, which adds complexity when implementing a similar program.

Usage

- In iSnapper, fishers can submit trips up to one day after the event. Currently, fishers in VicRLTag are encouraged to report by the end of the season and are unable to register to fish in a new season if tags from previous seasons are unreported. The potentially long timeframe between a user's fishing events and reporting in VicRLTag can affect the quality of data obtained and introduce reporting biases.
- The minimum data required from anglers to submit a catch report in iSnapper included time submitted, trip start and end times, number of fishers, and private or public launch location. The iSnapper program promoted that anglers could report in under 5 minutes, for example, while waiting retrieve boat at launch/port. Balancing the effort and time required of users to report catch and the quality of data obtained will require VicRLTag to prioritise a few key factors and encourage as many anglers as possible to report on those key factors, while encouraging fishers to participate in the citizen science program to collect the less important information.
- Although fishers had the functionality to submit an electronic catch report for all target species of a fishing event in iSnapper, only harvested snapper were reported in the app. Therefore, prioritising and encouraging maximum reporting rates for key variables, such as catch and effort, should be a part of the revised VicRLTag to ensure the data collected is the most beneficial to sustaining the fishery and informing management decision-making.
- Metrics on app usage, such as features used and unsubmitted reports, were collected, but not analysed. Collecting information on how fishers use the app can help VFA to guide future app developments and enhancements and identify technical issues.

- Reporting a catch in iSnapper could be submitted by app or webpage. However, not many fishers submitted catch reports using the webpage. Collecting app metrics could inform and guide future developments, such as the phasing-out of under-utilised reporting methods (e.g., web portal) and investment in resources fishers use (e.g., the app for reporting).
- Fishers have access to a personal log of submitted reports within the app. Features of the app that allow fishers access to personal catch reports and statistics can incentivise participation and facilitate two-directional information exchange which is important in obtaining high participation and compliance rates in long-term programs such as VicRLTag.
- Submitted catch reports are unable to be changed or edited unless a fisher contacts an administrator to make changes e.g., correct errors.

Compliance and non-reporting

- Incentives for fishers to report catch in iSnapper were provided in the form of give-aways from sponsors e.g., tackle or gear draws. There was no net benefit to the number of catch reports submitted with and without prize incentives. Currently, there is little information available as to the motivations of recreational rock lobster fishers in Victoria to report catch and, therefore, the potential success of giveaways and incentives associated with a revised VicRLTag can only be speculated.
- The iSnapper program initially had an estimated 10% reporting rate (i.e., only 1 in ten snapper fishers used the app), which dropped to 5%. However, a 3-day open season in 2017 resulted in an increase in reporting rate to 12%. Once open season had been extended again, reporting rates declined and were at 2% in 2020. Therefore, reporting rates were higher when anglers were more motivated. However, continual motivation and incentivisation was needed to keep anglers participating in the program. The VicRLTag program does not have a capture/recapture survey to estimate reporting rates like iSnapper. However, in the 2019/20 season compliance officers checked 132 of 4395 (3%) VicRLTag catch reports of which 76% were reported and only 24% of these had accurate carapace length reported.
- A lesson learnt from the iSnapper program was that obtaining a high reporting rate is an uphill battle with voluntary reporting. Obtaining the support of occasional fishers on board is especially challenging. The lack of a mandatory reporting framework with compliance regulations was a problem for getting substantial backing behind the iSnapper program. The preference would be to have the iSnapper program mandatory rather than voluntary. A mandatory program would allow enforcement to conduct compliance checks on the water with trip logs started before launching a

boat. The VicRLTag program is mandatory and to encourage a high level of compliance should be implemented with regulations that support compliance checks at landing sites.

Validation

- Electronic catch reports made with iSnapper are compared with creel survey in a capture/recapture method of data validation. In cases where data could be compared there were few discrepancies, and it was generally very accurate. Cross comparison of catch between an independent creel survey and the iSnapper app detected no significant differences in the reporting methods (NOAA 2019).
- An education strategy was launched to inform fishers of the importance of submitting a trip and partake in a creel survey too.
- Effort was estimated from trailer counts in roving surveys.
- The app is primarily used by avid fishers.

App Development

- A social and economic survey that asked more information including depth fished, discards, release condition, and fishing method was available for fishers to complete at any time using a button in the app. A social and economic survey built into the VicRLTag app could collect additional information on the fishery and fishing behaviour. However, is not the core objective of the app and will increase the effort requested of fishers. Therefore, a once a season or end of season survey rather than a survey constantly available to fishers may balance the demands on fishers with information collection if a social and economic survey is desirable in the revised VicRLTag app.
- A trophies feature was developed where fishers could upload pictures, record the size of catch and share the catch details with others. This trophies feature was not used by fishers, while additional built-in features, such as tides, also had limited user uptake. iSnapper was taken up by fishers to report snapper catch only. Therefore, features that were difficult to develop were not used by anglers in iSnapper. Focusing VicRLTag on obtaining the key catch and effort information rather than other features that may not be used by anglers or may be distractions could increase the reporting rate and reduce the likelihood of investing in redundant features. Ideally, stakeholder consultation will be conducted to determine the features anglers will utilise to incentivise participation in VicRLTag.
- When developing the app, be aware that programmers have a specific audience e.g., gamers. The purpose of the iSnapper app is for data collection and it is important to know the audience you are

engaging with and cater to their interests and needs. Tracking and assessing app metrics will identify features that are under-utilised by anglers and can be removed or changed in the future.

Communication

- iSnapper developers partnered with a couple of recreational fishers to advocate, educate, and promote the program. These partners can assist in countering 'trolling' comments and combat misinformation within the recreational fishery. Stakeholder engagement should form an integral part of the implementation of the revised VicRLTag app.
- The iSnapper program was promoted in magazine articles, advertisements, mail-outs and on radio programs. Communication in local fishing forums was the best method of communication for promoting the app. A strong media campaign to promote the revised VicRLTag app and educate anglers on the benefits will be important to motivate and incentivise uptake and participation.

MyFishCount (South Atlantic Fishery Management Council, USA) and iAngler (Florida, USA)

Program	**Contact Name**	**Affiliation**	**Date of interview**
MyFishCount / iAngler	Brett Fitzgerald	Angler Action Foundation	2/2/21
	Chip Collier	Deputy Director for Science South Atlantic Fishery Management Council	

General Comments

- The MyFishCount program was initiated due to short and competitive snapper seasons e.g., fishers ran out of fuel and were fighting for car parks at docks. There was no reporting program in place and management was based on estimated landings, which resulted in a zero-day open season in 2016.
- The primary objectives of the MyFishCount program are to obtain information and trend data on the fishery. Obtaining an estimate of total catch is not an objective in the current framework of voluntary reporting and would require a mandatory framework that is difficult to implement on a regional (multi-state) scale.
- A lesson learnt from the MyFishCount program was that, when developing an electronic catch reporting program, it is important to have real and measurable goals. The aims and objectives of VicRLTag should be clearly developed and communicated to stakeholders.

- At the on-set it is recommended that set-up and on-going costs are established and the measures of success/failure at specific time-steps (e.g., 1, 3, 5 years) are developed. Establish and understand both real and measurable goals. There is no need to re-invent the wheel with reporting programs. A plan for measuring program success, potential developments and revisions should be developed for VicRLTag.
- The raw number of app users and volume of records required to make an app successful is higher than was initially anticipated in the MyFishCount program. The field of dreams concept whereby if you build it, they will come cannot be taken. Actively advertising and selling or communicating the benefits of the recreational catch reporting program to fishers is required and reliant on the use of specialties, such as data scientists and universities, to supply information to fishers. A communication plan to promote the revised VicRLTag app and educate anglers on the benefits will be important to motivate and incentivise uptake and participation.
- Although the MyFishCount App is currently used for voluntary reporting, the app was developed to support both voluntary and mandatory reporting programs. If it was to be applied in a mandatory program, which aims to achieve increased compliance, then offshore reporting would have to take place and a relevant compliance policy in place. A well-developed compliance policy is necessary to get compliance officers on board. Comparison and dockside (mark recapture) surveys will be necessary to validate the data reported electronically. The VicRLTag program should have sufficient compliance regulations in place to support and enforce mandatory reporting. Assessment of the feasibility of introducing validation methods such as mark recapture surveys to improve estimates and measure non-compliance should also be explored.

Usage

- Catch reports submitted in MyFishCount are locked and not editable by the fisher after submission. Fishers must contact the program administrators to make changes to their reports. In the iAngler app, the data is locked and not editable by fishers after 3 months.
- Fishers who have incomplete trips in MyFishCount receive notification to close. Trips are made invalid and removed from analysis if they are not closed after a certain time.
- MyFishCount has a clear and transparent data policy outlining what data is and is not used for and confidentiality of information. For example, the scale of the geographical area fished that will be released in an analysis is fundamental to building trust with anglers. Communication of a VicRLTag data policy to stakeholders can encourage increased reporting rates as trust is established and fisher expectations are informed.

- In MyFishCount App the reporting of fine-scale spatial data is unnecessary. Instead, fishers can provide coarse-scale information or place names rather than co-ordinates. A data policy detailing that data will be aggregated to a coarse-scale for publication could encourage VicRLTag users to report fine-scale spatial data and promote the uptake of GPS location tracking in the future.
- It is the opinion of MyFishCount developers that the program asks too many questions to fishers. In retrospect it would be better to use with fewer fields that focus on the central information required. The trip and catch fields asked of fishers are (Collier and Fitzgerald 2019):
    - Trip Information: Trip ID (auto-generated), Username (auto-generated based on user), Email (auto-generated based on user), Trip Name (auto-generated by app can be edited by user), Authorization Number (auto-generated), Status (auto-generated), Trip Type (clickable box, selected by user), Target 1 (drop-down, selected by user), Target 2 (drop-down, selected by user), Departure Date (auto-generated by app can be edited by user), Arrival Date (auto-generated by app can be edited by user), Nearest City (drop-down, auto-populated based on last trip can be edited by user), State (drop-down, auto-populated based on last trip can be edited by user), Port Type (drop-down, selected by user), Hours Fished (drop-down, selected by user), Minutes Fished (drop-down, selected by user), Vessel Name (auto-populated based on last trip can be edited by user), Vessel Number (auto-populated based on last trip can be edited by user), Latitude (auto-generated based on nearest city), Longitude (auto-generated based on nearest city), Percent of Time with Hooks in the Water (drop-down, selected by user from list), Abandon Reason (drop-down, selected by user from list), Abandon Date (auto-generated by app can be edited by user), Comments (user created), Date Created (auto-generated by app), Last Updated (auto-generated by app), Verified (auto-generated based on Administrator), Reporting Method (selected by user), No Anglers (selected by user from list), Verified By (auto-generated based on Administrator).
    - Catch Information: Catch ID (auto-generated), Trip ID (auto-generated), Username (auto-generated based on user), Email (auto-generated based on user), Trip Name (auto-generated by app can be edited by user), Authorization Number (auto-generated), Status (auto-generated), Trip Type (clickable box, selected by user, Private, Charter, Headboat, or Test), Target 1 (drop-down, selected by user from list), Arrival Date (auto-generated by app can be edited by user), Nearest City (drop-down, auto-populated based on last trip can be edited by user), State (drop-down, auto-populated based on last trip can be edited by user), Port Type (drop-down, selected by user from list), Hours Fished (drop-down, selected by user from list), Minutes Fished (drop-down, selected by user from list), Vessel Name (auto-populated based on last trip can be edited by user), Vessel Number (auto-populated

based on last trip can be edited by user), Catch Latitude (pin dropped by user), Catch Longitude (pin dropped by user), Angler (auto-populated can be edited by user), Species (drop-down, selected from list by user), Catch Status (clickable box, selected by user), Caught Time (auto-generated can be edited by user), Length (entered by user), Length Type (clickable box, selected by user), Weight (entered by user), Depth (drop-down, selected by user), Hook Type (drop-down, selected by user), Hook Location (clickable box, selected by user), Release Treatment (drop-down, selected by user), Release Reason (drop-down, selected by user), Comments (entered by user), Date Created (auto-generated), Last Updated (auto-generated).

The identification of a few key catch and effort variables in VicRLTag and synthesising the reporting process could increase reporting rates by reducing the effort required of fishers to submit a catch report. It is preferred to collect a few variables with good reporting rates than many variables with low reporting rates to improve the robustness of the data.

- Incentives for fishers to report catch in the MyFishCount app are:
    - Personal catch records and statistics accessible to fishers within the app. Data filter functions allow anglers to explore data in iAngler including the range of fish caught, successful fishing trips, fishing trips with a specific number of a species caught, and trips with a specific target species. MyFishCount has automatically created reports (weekly or monthly) for anglers.
    - Prize draw: participants who log trips go into a draw to win small prizes e.g., t-shirts, tackle gear.
- MyFishCount incentives are used to get anglers involved in the program. Mandating reporting would be a tremendous step. States have the resources to mandate reporting, however, for regional programs mandatory frameworks are more difficult to implement.
- It is important to that program developers and managers be aware of the motivations of fishers in the program and cater incentives to appeal to their motivations. There are idealistic motivations (conservation) and realistic motivations (benefits). Little information available on the motivations of VicRLTag users or the incentives that would motivate fishers to submit catch reports or participate in the voluntary citizen science program.

App Development

- The MyFishCount app was developed with the web-platform and app syncing up. However, two-directional syncing made the app slow to use and was changed to one-directional syncing with the app syncing to the website. The VicRLTag app should aim to have app and web platforms syncing

up if the infrastructure is adequate to support it without creating a substantial time lag in using the platform. It is possible that if the app is too slow and difficult to navigate due to syncing, participation rates and user engagement will decline in time due to fishers losing motivation.

- Initially fishers required substantial assistance to use the MyFishCount app, with many users failing to follow instructions. However, as the program became established most of the ongoing assistance has been users forgetting their username and log-in details which spurred the development of automated log-in. Focusing on what people need to do and making the process as easy as possible has been essential for promoting up-take. Readily available technical support during the initial implementation of the new VicRLTag app will be important to ensure bugs and issues are addressed early. Some user workshops and education strategies, such as user guides, may help build fisher confidence and promote accurate reporting in the new VicRLTag app.
- MyFishCount developers recommend that app components as stripped back as possible and priority given to core information, which can be complemented with voluntary information.

Communication

- A large-scale marketing strategy to recruit participants was rolled out with the release of the MyFishCount program. Webinars had only small participation rates. Rather, dockside information was better for encouraging participation. Uptake in the MyFishCount app increased when engagement activities were being conducted. It was important to get in front of people, such as at fishing club meetings, and repeating the message to get fishers on-board and participating in the MyFishCount program. An assessment of the success of current outreach strategies used in the MyFishCount programs is currently being undertaken by a graduate student.
- A monthly report from the MyFishCount database is produced and sent to the email addresses of users.
- The developers of MyFishCount recommend full-time marketing and data staff to promote uptake and analyse the data. The VicRLTag program should develop communication and data analysis plans that are covered by on-going operational costs of the electronic catch reporting program.
- The narrative that is marketed to fishers is important. The communication of a narrative that conveys the benefits of electronic catch reporting programs to fisheries can help gain support and counteract some negative responses. For example, a narrative communicated to fishers that geographic information can assist managers to protect fishing holes under pressure to provide access to multiple users, including wind farms developments, can encourage fishers to provide fine-scale information.

- The MyFishCount program partnered with Yamaha to produce video on why it is important to report catches.

Snapper Check (Alabama, USA)

Program	**Contact Name**	**Affiliation**	**Date of interview**
Snapper Check	Colonel Scott Bannon	Director of the Alabama Marine Resources Division (MRD)	3/2/2021
	Kevin Anson	Chief Fisheries Biologist Alabama Marine Resources Division (MRD)	

General Comments

- When the Snapper Check program commenced in 2014 there were options for fishers to report via app, a paper-based log that was placed in a box at selected sites (with carbon copy for fishers), through a call centre and on a website. In 2020, fishers could report by paper with drop off boxes, electronic app and website portal. In 2021, the paper reporting will be phased out as it is only used by 8% of anglers and usually only when compliance officers were at the port. Following removal of paper reporting, fishers must report before leaving water, reducing the opportunities for reporting on shore and non-compliance.
- The project had NOAA funding for the first 2 years of $10 000 for the electronic components of the program.
- Quality assurance and quality control (QA/QC) of data is a valued part of the Snapper Check program that is time consuming, and the program could benefit from a full-time data analyst on staff. Given the type and quantity of data that is obtained in Snapper Check, and in electronic catch reporting generally, having a plan for the QA/QC of the data obtained by electronic catch reporting is important from the outset.
- There are 2 species that have voluntary reporting within the Snapper Check app. Scientists were unhappy with the data being obtained (~30-40 trips logged a year) for these species which was insufficient for effective quota management, resulting in shorter open seasons. In 2021, the 2 species will move to mandatory reporting in the Snapper Check app with the objective of obtaining more data to inform management. While the VicRLTag program is mandatory, having compliance regulations that support enforcement in place will be necessary to encourage the high compliance rates necessary for informing decision-making.

- It is the opinion of the Snapper Check leaders that the Mississippi Tails 'n' Scales program is the ideal electronic catch reporting program except for the logistical support needed to implement the reporting framework into larger and more diverse fisheries:
    - The benefits of the Tails 'n' Scales are that the hail in/hail out (register the start and end of a trip) process allows for boat-based compliance checks as a trip has to be started. In Alabama Snapper Check, compliance officers are unable to make inspections until a boat has reached land. This makes compliance more difficult and less successful. For example, stand-offs arising between compliance officers onshore and fishers on boats remaining in the water. A hail in/hail out system is more likely to have people report from home than the current VicRLTag requirements as fishers must close the trip before they are able to start a new one and have an open trip for compliance checks.
    - The difficulty in applying a similar Tails 'n' Scales system in Alabama is there would be substantial administrative burden to implement due to the larger fishery. The Alabama snapper fishery is also more diverse including a higher number of tourists and a shore-based fishing component.

Usage

- Fishers are encouraged to report via the Snapper Check app–either with their own smartphone or the phone of a friend or family member–and are required to report prior to landing. There is a small proportion of fishers that call their spouse before landing to report catch on their behalf. Generally, fishers have access to smartphone and can find a way to report using the Snapper Check app before landing.
- This year (2020) has had the highest number of private vessels reporting catch (~11 500 vessel reports) in the Snapper Check app.
- The Snapper Check app has features, such as regulation notifications and weather information, that provide incentives for fishers to use the app. Fishers can also re-purchase their annual licences and store records of licencing and documents in the Snapper Check app.
- Metrics on user interactions with the Snapper Check app and website are collected but have not been data mined at this time.
- The app and website are synced together. The revised VicRLTag app should aim to sync fishers' records between reporting platforms if the infrastructure in place is sufficient to support it without slowing the app speed down. In addition, collecting metrics on VicRLTag app usage could help guide future app developments by identifying under-utilised features, fields where fishers stop participating over time and aspects that may require further improvement.

- Fishers can report offline in the Snapper Check app, if reception is not available, and the app with automatically submit the catch report once reception is available. The offline report is accepted by compliance officers in the Snapper Check program. Offline reporting capabilities should be built in to the new VicRLTag app to provide fishers with the opportunity to report catch while out of phone reception.

Regulations and non-compliance

- Enforcement of the Snapper Check program initially focused on education, where enforcement officers explained and went through the reporting app with fishers, and in some cases issued warnings. After the first year the regulations were enforced with fines. Once fines are issued the message quickly spreads among the fishers to use the Snapper Check app. A phased-in approach to new regulations for the revised VicRLTag could be used to gain fisher support for mandatory catch reporting and compliance checks at the point of landing.
- Fishers in Alabama were not used to mandatory reporting, however, embedding the program in the State hunting app (Outdoor Alabama) for game catches may help to normalise reporting.
- Snapper Check regulations require vessel captains to ensure a catch report has been made for the vessel prior to landing. There is growing component of shore-based fishing where the fishing licence or conservation identification number is linked to the Snapper Catch report. In the absence of a licence, the creation of a unique identifier (e.g., number) that is automatically given to each fisher in the VicRTag program upon registration would provide an additional point of identification other than user email address, which is currently used to identify fishers and their accounts.
- The database of Snapper Check trip reports is available to compliance officers. However, there are clear lines between the roles of compliance and biologists and, generally, the Snapper Check database is not accessed to monitor compliance.
- Submitted Snapper Check records are locked and there are no editing controls provided to fishers in the app. Any changes that a fisher wants to make to the records submitted in Snapper Check need to be done by contacting the program staff to make the changes.

Validation

- There is an estimated 25–30% compliance rate in the Snapper Check program. In some cases, anglers at dock do not have the Snapper Check app downloaded when compliance officers conduct a check.

- There is a reporting bias in the Snapper Check program. When fishers see compliance officers at ports and docks, they are more likely to submit a catch report than if compliance officers are not observed prior to landing.
- Dockside capture/recapture surveys are used to collect complementary information that is used to validate Snapper Check app reports and estimate biases. The data collected is used to adjust estimates of catch, effort and catch rate. There are 18-20 full time staff in summer with 15-20% time allocation for conducting surveys to validate Snapper Check data. The VicRLTag program should develop a plan for validating data collected with the app in the future to ensure best practice standards.
- Cameras at docks have been used to estimate the number of trips and anglers. The estimate from cameras matches the estimates obtained by the Snapper Check app.
- The Snapper Check program leaders consider a good statistical design is necessary to measure biases and compliance from which estimates on catch and effort can be made for sustainable management of the fishery. If the capture/recapture surveys are well designed, it is generally accepted that the estimates derived are close to the real numbers. A strategy for estimating biases and compliance rates in VicRLTag should be developed.

App Development

- Fishers are not asked for spatial information related to catch in the Snapper Check program. The high variability in reported catches from different management zones in VicRLTag since the program was implemented in 2017/18 supports the need for spatially resolved catch and effort reporting in Victoria.
- The Snapper Check app stores user details from the initial account set-up to autofill on future catch reports e.g., licence number. The time required to complete a report is ~15 seconds.
- The Snapper Check app auto-updates as new versions are available. The VicRLTag app should also automatically update versions to keep current information available to anglers and efficiently resolve technical issues.
- Dashboard/web portal controls exist for the Snapper Check program leaders to stop and start app features with the open and close of the fishing season.

Communication

- All available media outlets were used to promote the Snapper Check program and get fishers on-side during the introduction of the program e.g., articles, local radio shows, emails to licence

holders, fishing forums, public meetings, and QR (quick response) codes linking to program website were printed on business cards.

- There are no follow-up or end of season surveys with anglers in the Snapper Check program.
- Fishers can track weekly effort against the previous two seasons on the Snapper Check website.
- People like having information and a continuous communication strategy aimed to show that the Snapper Check program is doing something for the fishers has been implemented highlighting how the information is being used. Continuous communication with fishers includes targeted articles, radio shows and Facebook live question and answer sessions with the chief scientist and director. The VicRLTag program should develop a communication plan for the implementation of the revised program that communicates the benefits of the program and how the data will be used. The communication of key findings from the VicRLTag program should also be included in the communication plan. Regular interactions between managers and scientists with stakeholders should also be established.
- The director and chief scientist directly take feedback from fishers and make time to interact with fishers. Although there was a call centre where reporting could take place as part of the initial program, it has been largely under-utilised and phased out. Rather fishers can identify and communicate with the people leading the program, thereby, building a trusting relationship that can improve compliance. Direct contact between program leaders and fishers also helps identify and resolve technical issues promptly before fishers are lost and deterred from reporting.
- The narrative communicated with fishers is made personal. For example, the Snapper Check data is needed to make better decisions for you. Regular in-person meetings and a designated person representing the program can emphasise that there is no big brother concept, there is no negative objective directed towards the fishers (e.g., shutting them down), and that there is a purpose and value to the information the program provides for all stakeholders. The Snapper Check communications leverage off the special place snapper have in the culture of Alabama and the hearts and minds of the fishers.

Tails ‘n’ Scales (Mississippi, USA)

Program	**Contact Name**	**Affiliation**	**Date of interview**
Tails ‘n’ Scales	Trevor Moncrief	Finfish Bureau Deputy Director, Mississippi Department of Marine Resources (MDMR)	9/2/21
	Eric Gigli	Marine Fisheries Scientist, Mississippi Department of Marine Resources (MDMR)	

General Comments

- The Mississippi Snapper fishery was subject to limited open days per season (~11 days and as low as 3 days in one year), which has eroded anglers trust in the management of the fishery. Consequently, fishers were looking for a program to report catch and improve data for decision-making which led to the creation of Tails 'n' Scales.
- The Tails 'n' Scales program is based on trip reporting where fishers register a trip (hail in) that allocates a unique identifier (code) for that trip, which is subject to compliance checks at sea, and lasts 24 hours. The pre-registration of an intent to fish "hail in" in the VicRLTag program would support water-based and landing site compliance checks and encourage fishers to close fishing trips by reporting catch after the fishing event. Trip reporting in VicRLTag would provide proof of fishing intent, which could replace the plastic tags that are currently used. The absence of proof of fishing intent (e.g., plastic tags or hail in trip registration) and regulations that allow fishers to report after the event (e.g., anytime until the next season) in the VicRLTag program fails to support compliance checks or encourage increased compliance.
- The developers and managers of the Tails 'n' Scales app consider the electronic catch reporting approach to not be a silver bullet, however, works in this case with complimentary methods, such as data validation built into the program. In revising the VicRLTag program it is important to consider and plan for implementing a suit of supportive strategies including communication, data analysis, compliance, and validation to enhance the effectiveness of the electronic catch reporting program.

Usage

- Fishers can report via the Tails 'n' Scales app, a website portal and through a phone call centre. However, 90–95% of fishers report using the Tails 'n' Scales app instead of website or phone.
- User interactions with the Tails 'n' Scales app is only assessed in terms of app downloads and versions. Metrics for Tails 'n' Scales app usage are not collected. Recruitment and participation are assessed via trip reporting records due to the high level of compliance achieved in the program.
- Auto-filling of some fields in the Tails 'n' Scales app is possible to reduce reporting effort required of the fishers.
- The trip logs reported in the Tails 'n' Scales app are not able to be editable by fishers. Corrections can be made by contacting the biologists operating the program. However, a summary page is provided to anglers to confirm details before the trip is submitted in the Tails 'n' Scales app to reduce unintentional errors.

- On closing a trip report in the Tails 'n' Scales app, anglers are asked if a trip was taken. If yes, anglers provide the number of target species that were captured/harvested/released, the habitat the fish were caught in and number of anglers in the vessel.

Regulations and non-compliance

- Participation in the Tails 'n' Scales program was voluntary at first with compliance officers issuing warnings rather than citations for non-compliance. This was accompanied by an education campaign that promoted the reasons for the program and benefits to anglers.
- Over the past 2 years of the Tails 'n' Scales program there has been 95% compliance based on the presence/absence of trip logs.
- Managers monitor the estimated catch rate calculated from Tails 'n' Scales trip reports and provide weekly updates throughout the season.
- Access to trip logs and user information from the Tails 'n' Scales program are not provided to compliance officers/enforcement to increase the trust and confidence of anglers to provide data. Limiting access to the data ensures compliance officers are unable to track specific people. Instead, compliance officers must intercept anglers at the ports.

Validation

- Validation of Tails 'n' Scales app data is built into the reporting program with access point surveys conducted by biologists. Surveys are allocated based on ramp pressure and assess the accuracy of trip reports which are required to be completed before the return to dock. The surveys provide a misreporting/non-compliance estimate for correcting the catch, effort and catch rate data collected in the Tails 'n' Scales app. A plan for validating the VicRLTag data should be developed for future implementation to assess compliance rates.

App Development

- The Tails 'n' Scales program was started in 2015 with a simple structure. User-friendly advancements since the program roll-out have resulted in more people reporting in the Tails 'n' Scales app.
- On-going servicing of the Tails 'n' Scales app and underlying program infrastructure has been required. The VicRLTag program should establish a plan for on-going costs such as app updates to ensure the long-term maintenance and relevance of the program.

- The Tails 'n' Scales program leaders consider that anglers can be asked between 5 and 9 questions before they are lost in the app and reporting accuracy suffers. Prioritising the key catch and effort factors and encouraging anglers to report at least the key factors will be important to elevate the reporting rate. Factors not identified as key in VicRLTag should be in the within the voluntary citizen science component of the program.
- Future development could include regular updates of quota taken within season for fishers to plan season. Currently, near real time updates are not provided to avoid changes in fishing behaviour e.g., a rush to fish.

Communication

- Feedback on the Tails 'n' Scales program is provided to anglers in the form of a red snapper annual report and public presentation. Similarly, VicRLTag currently produce an annual report and VFA present key findings at stakeholder meetings.
- The Tails 'n' Scales program has an end of season survey (Survey Monkey platform that is emailed to fishers) that is conducted to gain stakeholder feedback. An end of season survey is a possible addition of VicRLTag that could be used to collect contextual information on the fishery that can help interpret the data, such as social and economic factors, the influence of covid-19, and fisher satisfaction with the app and program.
- Anglers can view their previously submitted trips in the Tails 'n' Scales app as incentive to report.

Fangstjournalen (Denmark)

Program	**Contact Name**	**Affiliation**	**Date of interview**
Fangstjournalen	Christian Skov	National Institute of Aquatic Resources (DTU Aqua)	15/1/21

General comments

- Although there is an increase in the use of recreational catch reporting apps, electronic catch reporting fail to solve all the problems related to measuring catch and catch rate and should not be stand alone. Rather apps should be used in combination with traditional methods with the objective of achieving fisheries specific corrections to catch rate data. Skov et al. (2020) outline the limitations and development of catch reporting apps that promote data quality and utility, while European Commission (2020) report compares apps and discusses the best practice for developing electronic catch reporting programs.

- The annual proportion (~5%) of participants reporting catches into the VicRLTag citizen science program is similar to anglers that use the Danish catch reporting app (~5%). These participants that use the Fangstjournalen app are experienced fishers who rate angling as an important hobby. The sample of participants will influence the data, such as include avidity bias, and limit the ability of researchers to derive information on the overall fishery from the sample data.
- Traditional cultural practices play a part in uptake and persistence with reporting programs. For example, in Denmark hunters have been required to report catches for generations and are generally accepted within society. Catch reporting will normalise in cultural practices in time.
- The Danish app developers recommend reporting programs are developed with the app and website to be responsive to each other (two-directional syncing) rather than stand-alone platforms. In the past, stand-alone platforms have been developed due to technical issues, however, integrating platforms is recommended if it is possible.

Usage

- When creating an account (signing up), the Fangstjournalen App asks participants initial screening questions: years/experience, importance of angling, and rate your skills (1-10). VicRLTag may benefit from a couple of screening questions at the start of each season, for example: how many days you fished last year which could assist researchers to quantify and correct effort measurements. Screening questions could also profile the fishers signed up for the citizen science component of VicRLTag to allow researchers to extrapolate and correct the data obtained to be representative of the whole fishery, such as correct for behavioural differences between fishers who opt-in and those that do not.
- When the Fangstjournalen app started 5 years ago there was strong uptake, which gradually declined before stabilising at ~1500 new participants each year. The VicRLTag app also has turn-over of participants with ~2000 new participants in Season 3 of the reporting program, while ~4000 participants did not re-register to participate from the previous two seasons.
- Submitting catch reports in Fangstjournalen can be by an app or website. In Fangstjournalen, more people report catches on the website than the app, which reflects the demographics of the fishery: older and experienced anglers. VicRLTag has multiple platforms for participants to report catch, such as an app and paper-based (for registered users) reporting, that cover potential technical issues with reporting from the range of electronic devices available to fishers.
- The Fangstjournalen app is designed to encourage Danish fishers to report catch on a boat by obtaining benefits from the app, such as information about the site regulations, notifications of closed area and alarms if they are approaching restricted areas. The app uses GPS locations to

make reporting for the fisher as easy as possible and provide these benefits. Although, feedback from the Victorian Rock Lobster Fishery is hesitant to include GPS capabilities in the current development of VicRLTag due to privacy concerns and the additional complexity to reporting it creates, the benefits and utility should be considered for future development of the program.

- The Fangstjournalen app contains many records of zero catch fishing trips. Fishers log a fishing trips with a start and end. When the trip is ended, irrespective of catch, the statistics are automatically displayed to the fisher to emphasise the importance of reporting the information (catch, effort and catch rate).
- In the Fangstjournalen catch reporting program, a weekly report is automatically generated on app users, catch reports, fishing trips etc. This is a useful feature that allows developers and managers to track the uptake, retention, and persistence of participants while also following catch, effort and catch rate trends.
- Benefits to fishers that promote Fangstjournalen App usage include:
    - Users can access and conduct basic analyses of the whole (raw/uncleaned) dataset with filter functions. Ideally, this data would undergo some quality control process.
    - An electronic logbook allows fishers to explore their personal catch statistics. There are no reporting time limits – fishers can add historic catches to build their catch statistics. The app has records back to the 1970s.
    - Fishers can set the data usage conditions, for example, private reports can only be used for research and public catch records can be more widely used and released. It is important to have a data usage framework that fishers are well-informed of. When fishers feel informed and in control of their privacy, they can be more inclined to contribute information.

Validation

- Creel surveys are used to collect information on the fishery and fishers which are used to validate and develop corrections for the data collected in the Danish app.

Communication

- Build a strong narrative that stakeholders are all on the same page. For example, information is needed to protect fish; fishers can help collect the information and navigate the way forward that can evaluate regulations and maintain sustainable fisheries.
- Develop a feedback system for communication. It is time-consuming but important to establish a two-way dialogue system. This is a good way to discover any issues with the app and its functions

and remove possible social media backlash as these issues can be discussed and swiftly acted upon to maintain institutional integrity.

- A newsfeed is published once a week on the data. Posts to the newsfeed can ask fishers for feedback such as maybe can you help explain the trends or do these reports seem right in your experience etc. The newsfeed can also highlight interesting catches and data.

Appendix 4: Examples of apps

A more comprehensive list of free and paid commercial apps for catch reporting with >500 downloads is provided in Bradley et al. (2019).

NOAA catch reporting
https://play.google.com/store/apps/details?id=gov.noaa.nmfs.hmscatchreporting&hl=en_AU

iCatch https://www.theastgroup.com/au/case-studies/ast-icatch-fish-catch reporting-app-smartphones/

Atlantic HMS catch reporting https://www.fisheries.noaa.gov/resource/tool-app/atlantic-hms-catch reporting-app
SAFMC myfishcount https://www.myfishcount.com/

DFO Canada Internet Recreational Effort and Catch (iREC) reporting program http://www.pac.dfo-mpo.gc.ca/fm-gp/rec/irec-iarc/index-eng.html

Fångstdatabanken http://www.fangstdatabanken.se

Fangstjournalen www.fangstjournalen.dtu.dk

FishBrain www.fishbrain.com

Great Lakes Fish Finder http://www.sheddaquarium.org/Conservation-Research/Citizen-Science/Fish-Finder

iAngler http://angleraction.org/angleraction/login/auth

iFish Forever www.ifishforever.com

IGFA catchlog www.igfacatchlog.org

iSnapper http://www.harteresearchinstitute.org/isnapper

Mijn VISmaat www.mijnvismaat.nl

Snapper Check http://www.outdooralabama.com/mobile-apps

Appendix 5: Abundance Index Recommendation

Two legal sized abundance indices are currently used in the Victorian Southern Rock Lobster Assessment (for both Eastern and Western zones). The first is standardised CPUE derived from commercial logbooks. The second is a biomass estimate derived from the stock assessment model which integrates all available information including the standardised CPUE, length-frequency data and commercial and recreational catches.

A pre-recruit index is also calculated from a range of sources including observer data, fixed site surveys and voluntary recording by commercial fishers. This is a key component of the harvest strategy but collecting data of sufficient spatial and temporal resolution remains challenging.

VFA and stakeholders have suggested the development of an additional abundance index derived from the recreational fishery. This would provide additional independent verification of the existing indices. If of sufficient quality this could also be utilised in the stock assessment model as an additional abundance index.

A key aspect of any abundance index is to avoid inclusion of erroneous or low-quality data. Consequently, abundance data collected from the recreational fishery should be a voluntary field. This avoids low accuracy data being entered by fishers who do not want to enter data or realise they do not accurately recall the information but are forced to record something.

Calculation of an abundance index from the recreational fishery requires two key pieces of information, firstly the number of observed lobsters, secondly some measure of effort. For the number of observed lobsters, it would be possible to ask respondents for size-differentiated data (e.g., how many undersize lobsters) and such data would be particularly appealing due to the importance of the undersize index. However, the fact that lobsters may be observed with low accuracy (e.g., deep within a crack) means that a fisher's ability to differentiate between legal and sub-legal animals may be limited. Consequently, it may be preferable to simply to assess the number of non-retained lobsters observed.

Sample Question

- How many lobsters did you observe while fishing and did not harvest?
- How much time did you spend actively fishing for lobsters (units to be decided; likely hours)?

In the app, provide a drop-down menu for fishers to select from numerical choices that separate true zero, that is no lobster were observed and non-retained, v. non-report in the database.