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2025 review of potential methods for estimating recreational harvest of rock lobster

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PLAIN LANGUAGE SUMMARY

The National Panel Survey (conducted every 5 or 6 years) is the main approach used to estimate recreational harvest nationally. However, only a small proportion of the fishers recruited for past National Panel Surveys have targeted rock lobster, so harvest estimates have been very uncertain.

In this study, a technical working group reviewed alternative approaches to get annual estimates of rock lobster recreational harvest. An improved National Panel Survey or a mandatory registry sample frame panel survey supported by creel surveys were ranked highest for CRA 1 and CRA 2. But the other CRA stocks have more pot fishing, which is poorly sampled by creel surveys. So for these stocks a mandatory registry sample frame panel survey was considered the most viable annual survey approach.

Self-directed (voluntary or mandatory) reporting via an app, mandatory horn tagging or a voluntary registry sample frame panel survey were also reviewed but considered less viable.

EXECUTIVE SUMMARY

Tuck, I.D.[1]; Hartill, B.[1]; Baird, C.[1]; Breen, P.A.[2]; Cryer, M.[3]; Curtis, S.[4]; Edwards, M.[5]; Holdsworth, J.C.[4]; Maggs, J.Q.[6] (2026). **2025 review of potential methods for estimating recreational harvest of rock lobster.**

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Understanding the level and composition of recreational harvest is an important aspect of managing shared fisheries, to inform total removals in stock assessments, guide the allocation of catch limits, and to manage allowances that have been set.

Fisheries New Zealand currently undertakes a National Panel Survey (NPS), in which recreational fishers are recruited by stratified, probabilistic household screening based on a national dwelling database. This is done every 5 or 6 years to estimate harvest in all of New Zealand's substantive recreational fisheries. An ongoing programme of monitoring at boat ramps around the country is used to monitor trends between these national surveys and to estimate mean weights. These approaches provide robust harvest estimates for the main recreationally fished stocks, but more specialised fisheries (including rock lobster) tend to have lower participation within NPS panels, leading to more uncertain harvest estimates.

A range of current tools and future options for recreational rock lobster harvest estimation were reviewed and scored against agreed evaluation criteria by a technical working group within the Marine Amateur Fisheries Working Group. Scores were compared across individual criteria and combinations of criteria in simple utility functions.

In CRA 1 and CRA 2 the methods considered most viable for providing an annual estimate of recreational harvest were either an improved National Panel Survey (increasing survey frequency and the numbers of CRA fisher panellists) or a mandatory registry sample frame panel survey to provide absolute estimates of harvest, supported by relative harvest creel surveys to provide relative harvest between absolute estimates.

The National Panel Survey is a well-established approach, and potential modifications have been identified (but not yet validated) that could boost rock lobster fisher participation. A mandatory registry sample frame panel survey has been demonstrated successfully in Tasmania, but would be a new approach for New Zealand, requiring the development of a registration system and some form of oversight to ensure a high level of compliance / participation monitoring, at least in early years. Development of a registry sample frame would simplify and significantly reduce the cost of the panel recruitment process. Both of these offsite surveys would also require some onsite sampling (such as the creel surveys) to estimate mean fish size.

A fishery all-site creel survey also ranked highly for providing an annual estimate of recreational harvest in CRA 1 and CRA 2, but relative harvest creel surveys conducted in conjunction with reasonably frequent absolute harvest estimates was considered a better option.

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Mandatory or voluntary self-directed app reporting, a voluntary registry sample frame panel survey and mandatory horn tagging were all considered less viable. Concerns about these approaches related largely to difficulties in scaling reported harvest to all fishers (leading to low precision and unknown bias), lack of public support and lack of previous successful demonstration elsewhere.

While the absolute harvest estimate approaches were likely to have equal viability around the country, it was noted that creel survey approaches were considered less suitable for rock lobster fisheries with significant recreational pot fishing (which is all areas except CRA 1 and CRA 2 with insufficient data to determine for CRA 7). For these stocks a mandatory registry sample frame panel survey was therefore considered the most viable annual survey approach.

1. INTRODUCTION

Recreational fishing is a valued pastime and food source for many New Zealanders, with recreational fishers accounting for a significant proportion of removals taken from some inshore stocks. It is important to understand the quantity and size composition of fish caught by recreational fishers, so that they can be accounted for by the stock assessments that inform fisheries management, and to help guide the allocation of catch limits between sectors and manage recreational harvest to the allocation. Other than landings taken from amateur charter and commercial fishing vessels, there is no requirement for recreational or customary fishers to report any marine catch taken under the amateur fishing regulations, so, currently, some form of survey is required to estimate this source of harvesting.

The primary survey instrument that Fisheries New Zealand uses to estimate recreational harvests is a National Panel Survey (NPS) which has provided estimates for about 99% of the recreational catch taken by New Zealand residents during the 2011–12, 2017–18 and 2022–23 (October) fishing years (Heinemann & Gray 2024; Wynne-Jones et al. 2019; Wynne-Jones et al. 2014). The reliability of the NPS survey for some finfish stocks has been corroborated independently and concurrently by fundamentally different aerial survey/boat ramp interview surveys in 2011–12 and 2017–18 (Edwards & Hartill, 2015; Hartill & Bian, 2020).

National Panel Surveys have been conducted only every five or six years since 2011–12, and the precision of harvest estimates for some rock lobster stocks has been poor because only small numbers of panellists have been recruited from these specialist fisheries. High uncertainty in recreational harvest creates uncertainty for management of fisheries, particularly when recreational harvests contribute a significant proportion of total removals. Uncertainty in harvest estimates increases with lower panellist numbers and lower harvest levels and, for some fisheries, where recreational harvests are very low, it may not be practical to estimate harvests with high precision. The level and trend of recreational catches have been identified as a source of uncertainty for several rock lobster stocks and is of particular concern for the northern stocks. Additional information is required to track trends in recreational harvesting from rock lobster stocks where there is a material level of recreational catch. This information is needed to better inform stock assessments and Ministers have acknowledged the obligation to manage recreational catch (on average) to the level of the allowance. There is active consideration being given to managing lobster stocks at much higher biomasses which is likely to lead to increases in recreational participation and catch.

In response, and to monitor harvest in relation to the allowance in response to a planned rebuild of the CRA 2 stock, a 5-year relative creel survey monitoring programme was started in 2019–20. Other potential approaches to estimate recreational rock lobster harvests were considered by the Marine Amateur Fisheries Working Group (MAFWG) in 2018, before the CRA 2 monitoring programme was started in October 2019.

This report documents a follow-up process that has built on and expanded the 2018 MAFWG process, forming a technical working group to consider and discuss a broad range of potential harvest estimation approaches, score the approaches against a set of agreed criteria, and rank the approaches in relation to their utility (as estimated through a combination of criteria scores).

Although the review of potential harvest estimation approaches was completed in 2023, finalisation of this report and its conclusions were delayed to enable incorporation of results from the 2022–23 NPS (Heinemann & Gray 2024) and the CRA 2 relative harvest monitoring creel survey (Maggs et al. 2024), given their relevance to this review, and consideration of an additional approach.

The overall aim of the work was to evaluate potential harvest estimation approaches for providing annual estimates of absolute recreational rock lobster harvest. While estimation is important for all rock lobster fisheries, it is most pressing for the northern fisheries (CRA 1 and CRA 2), and this was considered when identifying / evaluating approaches, although applicability to other CRA fisheries

was also noted. Recreational harvests taken from amateur charter vessels or commercial vessels under S.111 general approvals were considered out of scope for this review, as these are reported separately through existing systems.

2. METHODS

This review was undertaken as a MAFWG process (rather than a contracted research project) with key working group members invited to participate as members of a technical working group (Table 1). Participants were invited on the basis of levels of experience with recreational fisheries, relevant research in rock lobster fisheries and to ensure that both recreational and commercial perspectives were present. Participation was supported by Earth Sciences New Zealand (formerly NIWA), New Zealand Rock Lobster Industry Council Ltd (NZ RLIC), and New Zealand Sport Fishing Council (NZSFC) funding.

This technical working group met over a series of online (and one in-person) meetings between 2022 and 2024, to initially discuss and scope out the process, identify potential harvest estimation approaches and evaluation criteria, and finally to develop consensus about the relative merit of approaches through a moderated scoring process (Table 2). Potential approaches were identified given the national and international experience and knowledge of technical working group members, a recent Australian review (Twiname et al. 2022) and wider MAFWG discussion. During this process it was important to develop a common understanding of the methods required to implement each estimation approach and potential problems that could arise, based on the members' previous experiences of the technical and social challenges in designing successful survey methods. The process also identified some other potential approaches that were not considered appropriate or viable for rock lobster and were not evaluated further. The overall process was led by Fisheries New Zealand, with valuable contributions from all participants.

Table 1: Membership and relevant experience of the technical working group participating in this work.

Name	Organisation	Role/experience
Ian Tuck	Fisheries New Zealand	Chair of the MAFWG
Bruce Hartill	Fisheries New Zealand	Chair of the RLWG, fisheries scientist with significant experience in recreational fisheries research
Cliff Baird	Fisheries New Zealand	Fishery manager dealing with rock lobster
Paul Breen	Independent consultant on behalf of NZ RLIC Ltd.	Experienced fisheries scientist, involved in rock lobster research and stock assessment
Martin Cryer	Independent consultant	Ex-chair of MAFWG, fisheries scientist with significant experience in recreational fisheries research
Sydney Curtis	NZSFC	Recreational representative, fisheries scientist
Mark Edwards	NZRLIC	Commercial representative, CEO of the NZ RLIC
John Holdsworth	NZSFC	Recreational representative, fisheries scientist with significant experience in recreational fisheries research
Jade Maggs	Earth Sciences New Zealand	Fisheries scientist with significant experience in recreational fisheries research

A summary of the evaluated approaches is provided in Section 3, along with a brief description of approaches considered and dismissed, including the justification for this decision in relation to harvest estimation for rock lobster (Section 4).

Table 2: Timeline of the recreational harvest estimation approach review process.

Date	Topic	Location
8 June 2022	Initial presentation to MAFWG, and agreement to revisit the 2018 discussions	Online
18 January 2023	Introduction, specifying the issue, identification of potential harvest estimation approaches to consider and scoring criteria	Online
15 February 2023	Finalisation of approaches to evaluate and scoring criteria	Online
Early March 2023	Independent scoring	
24 March 2023	Scoring discussions	In-person
7 June 2023	Rankings from agreed scoring presented to the MAFWG	Online
28 November 2024	Feedback on the draft FAR	
November 2024 – January 2025	Further consideration of scores in the light of the 2022–23 NPS and additional evaluation of a Mandatory reporting app.	Via email

The evaluation of the selected approaches against the agreed criteria is provided in Section 6. Selection criteria covered aspects of:

- logistical requirements (approach prerequisites, the need for management or regulatory changes).
- additional survey needs beyond the core approach and potential dependencies on other concurrent survey data, including quantification of compliance or participation.
- level of confidence in the approach (previous successful application in New Zealand or overseas) and likely reliability of results (bias and precision).
- anticipated public support and buy-in (especially if that might detrimentally affect participation).
- fishery coverage (whether all fishing platforms and methods would be sampled), and whether the approach would also provide data for other species.

Criteria were independently scored (1–5: good to bad or yes/no as appropriate) by individual participants, and then these individual scores were discussed at an in-person meeting to identify group consensus scores. Scores for some criteria (agreed by the group) were combined in utility functions to rank the alternative harvest approaches. Cost was considered by the group, but given the uncertainties about how to account for the marginal costs of CRA monitoring within a multi-species survey, the costs of introducing new legislation, or participation/compliance surveys (and how this might overlap with existing MPI Fisheries Compliance activities), it was not considered that reliable costs could be estimated, and formal cost-benefit analyses were not conducted. Rather, the various requirements of the different approaches have been identified.

3. BRIEF DESCRIPTION OF RECREATIONAL HARVEST SURVEY APPROACHES

3.1 National Panel Surveys

The National Panel Survey (NPS) is currently the main approach used to estimate recreational harvests of all marine fishery species in New Zealand. The development of this approach was strongly influenced by lessons learnt from telephone diary surveys conducted in New Zealand and Australia up until 2001 (Hartill et al. 2004), and includes innovations developed by the National Research Bureau (NRB) and the MAFWG over a two-year design phase to address the limitations of these earlier surveys. The NPS has been conducted every 5 to 6 years since 2011–12 (in 2017–18 and 2022–23) and provides absolute estimates of recreational harvest, across all fishing methods and platforms.

The NPS approach follows a two-stage sampling design. The first phase is a face-to-face screening survey of over 30 000 randomly pre-selected households from around the country, which is used to

collect data on the prevalence of putative marine fishers in the population and to recruit over 5000 panellists to report their catch over the following fishing year. During the second phase, the recruited panellists are sent an SMS text on a regular two- to four- weekly basis to determine if they had fished since they were previously contacted. For those who responded that they did fish, a structured Computer Assisted Telephone Interview (CATI) was undertaken to collect fishing effort and catch data for any trips that occurred during that period. At the end of the fishing year, the selection probability for each panellist (calculated from the screening survey) was used to scale up their annual reported catch, so that they could be combined to provide an estimate of the harvest taken by all resident fishers in New Zealand during the 12-month survey period. A complete description of the methods used and results from 2022–23 (and previous surveys) is provided by Heinemann and Gray (2024).

The NPS provides estimates of numbers of fish harvested by species and area, and mean fish weight estimates provided by a concurrent onsite creel survey are used to convert numbers to total harvest weights for all of the commonly harvested fish stocks (e.g., Davey et al. 2024). Previous survey data suggests that diarists tended to overestimate the size of fish they retained when self-reporting fish weights (Ryan & Kilner 1994).

The NPS is designed to provide harvest estimates for all species, but regions of the country with a lower population density and niche or specialist fisheries are often not sampled well. All three NPSs have had low numbers of panellists reporting rock lobster harvest from most stocks, resulting in many important harvest estimates with relatively high coefficients of variation (CV), indicating marginal or low precision (Table 3).

Low precision estimates are also more likely when lobster abundance (and hence fisher success) is low, which is also when there is likely to be a greater management need for precise harvest estimates, especially for those stocks where recreational fishers account for an appreciable proportion of the harvest.

Before the 2017–18 NPS, simulations were used to assess whether increases in regional sample sizes and data weighting procedures could be used to cost-effectively increase precision for priority stocks, including some CRA stocks (NRB & SRA, 2017). Because the CV of an estimate is proportional to the square root of the sample size (the number of panellists participating in a fishery), substantial increases in the number of households sampled (to recruit more fishers) would be required to markedly improve the precision of CRA harvest estimates. These simulations suggested that, in the absence of a specific sampling frame for rock lobster fishers, using the previous approaches (randomly selecting an individual fisher from a household) it would be prohibitively expensive to improve the precision of NPS rock lobster harvest estimates by expanding or modifying the household screening survey.

Table 3: Rock lobster sample size, scaled harvest estimates and estimated coefficients of variation (CV) for the 2011–12, 2017–18 and 2022–23 National Panel Surveys. Estimates exclude landings from Amateur Charter Vessels or under S.111 general approvals.

	2011–12			2017–18			2022–23		
	Fishers	Harvest (t)	CV	Fishers	Harvest (t)	CV	Fishers	Harvest (t)	CV
CRA 1	32	23.79	0.30	33	15.50	0.48	15	8.00	0.49
CRA 2	66	40.57	0.24	33	14.21	0.36	25	9.99	0.31
CRA 3	26	8.07	0.33	30	12.21	0.26	10	5.74	0.51
CRA 4	68	43.36	0.17	72	41.26	0.23	44	32.58	0.39
CRA 5	43	41.72	0.23	57	40.08	0.21	41	38.59	0.26
CRA 6	–	–	–	–	–	–	–	–	–
CRA 7	1	0.23	1.03	1	0.09	1.00	3	1.41	0.54
CRA 8	6	6.03	0.68	20	14.66	0.40	23	10.45	0.34
CRA 9	22	17.96	0.30	22	17.07	0.34	10	4.5	0.43

Concerns over face-to-face interviews for panel recruitment related to COVID-19 in 2022 may have reduced survey participation, and new requirements by the telephone service provider to provide for easy "opt out" options may have facilitated a higher drop-out rate in the 2022–23 survey than experienced previously (Heinemann & Gray 2024). There is a risk that phone interviewer-led data collection may become less acceptable to the general public in the future.

The NPS approach is labour-intensive and expensive. After a panel is recruited through the face-to-face survey, cost-effective harvest estimates could be obtained by asking the panel to re-enrol for one or more further years, to report their catch and effort either via a continuation of the CATI data collection system or via unprompted online self-reporting (potentially providing annual estimates). Unprompted self-reporting data collection approaches were explored following the 2017–18 NPS (Heinemann et al. 2021) and are briefly described below. Given the low numbers of rock lobster fishers participating in the initial NPS survey, and declining participation in response to re-enrolment requests, it is unlikely that either of the reporting approaches described below would result in markedly more accurate and precise harvest estimates than the current approach. The precision of harvest estimates declined in these follow-on studies when previous panellists were invited to re-enrol voluntarily for a second survey year.

3.1.1 NPS panel retention study – non-CATI prompted self-reporting

Panellists were contacted at the end of the 2017–18 NPS survey and were asked to re-enrol for a further year (2018–19). Re-enrolling panellists were then sent monthly SMS texts over the following 12 months, asking whether they had fished. Panellists who responded "Yes" were then sent a link to an online catch effort reporting questionnaire that they were asked to complete, rather than being questioned by an interviewer following a structured CATI data collection process.

While the demographic composition and fishing avidity profile of the re-enrolled panel was broadly similar to the previous year's NPS panel, only 57% of the 2017–18 panel re-enrolled, which suggests that multi-year panellist enrolment is not viable. Further, only 32.8% of the 2018–19 panel self-reported at least one fishing trip in that year, compared to 53.1% of the fishers who participated in CATI interviews in the previous year. Those that did report at least one trip on-line, also reported fewer trips on average in 2018–19. This suggests that under-reporting could also be a significant issue when fishers are asked to record their own catch and effort, despite being prompted to do so. Declining participation by panellists over periods longer than 12 months will therefore likely result in lower precision harvest estimates, and a negative but unmeasured bias in estimates of harvest.

3.1.2 NPS panel retention study – prompted vs non-prompted self-reporting

Almost 80% of those who re-enrolled in 2018–19 were asked to re-enrol for a further 12-month panel survey (2019–20), so that harvest estimates based on prompted and unprompted reporting could be compared. The remaining 3143 fishers were randomly allocated into two equal sized samples, with one group being prompted by SMS to report any fishing activity, and the other group being provided an online app for them to use over the following 12 months, without any monthly prompting.

While the relative participant demographic/fishing method/species composition profiles reported by each method were once again broadly similar to those seen in the NPS survey, a significant source of bias was readily apparent in the unprompted catch app reported data. There was clear evidence that avid fishers were more likely to report their catch than less avid fishers, and the retention rate was lower for all avidity. Comparisons between the 2017–18 NPS and 2019–20 prompted and unprompted self-reporting surveys suggested that unprompted app reporting can lead to a substantial overestimation of recreational harvests, with poor precision.

The conclusions drawn from this study about the limitations of unprompted catch reporting are likely to be equally valid for other non-NPS data collection options that have been considered as part of this review, e.g., mobile app reporting and horn tagging.

3.2 Mandatory or voluntary registry-based panel surveys

The limitation of the NPS for rock lobster (and other poorly sampled species) derives from the need to probabilistically sample the whole New Zealand population (aged 15+) and the low proportion of panellists that are likely to participate in niche fisheries. A solution to this limitation is to develop a targeted database of recreational fishers (either generic or targeting specific species/stocks) through a voluntary or mandatory free registry, and then conduct a panel survey of fishers identified by this more targeted sample frame. A recent study in Germany suggested that *recruiting diarists from the list of permit holders may be more successful in terms of participation rates than recruiting from a general probability-based population survey* (Lewin et al. 2023).

A generic (all species) recreational fisher database would remove the need for an expensive NPS face-to-face household screening process but would provide little advantage (assuming similar overall panel sizes) in terms of harvest estimate precision for the main species, because the prevalence of households containing at least one fisher is reasonably high. However, a species-specific fisher database (e.g., provided by a rock lobster fisher registry) would provide an invaluable sampling frame for a targeted offsite panel survey, which could be used to provide more cost-effective precise harvest estimates than the current NPS. A recent Tasmanian offsite panel survey based on a sample frame of licence holders estimated total lobster harvest with a CV of about 8% by surveying 344 diarists, 1.8% of licence holders (Lyle et al. 2021). The harvest and associated uncertainty were estimated separately for eight sub-regions but, unfortunately, the numbers of survey panellists participating in each region were not reported. Sub-region level estimated CVs were 13–24% on the east coast (where 85% of the harvest was estimated) but much broader at 30–68% on the lightly-fished west coast (Lyle et al. 2021). Within New Zealand, surveys of this type would need to be stock-specific (or, at least, designed to give good spatial coverage of participants).

A targeted rock lobster harvest estimation panel survey would operate in the same way, regardless of whether a mandatory or voluntary registry was in place. As with the ongoing participation in the NPS (above), the acceptance and uptake of either registry is likely to vary with fisher avidity (more avid fishers being more likely to participate). Both approaches would still require onsite surveys to provide mean weight estimates (required to convert numbers to harvest weight) and to estimate compliance or participation with the underlying registry regime that this type of harvest estimation approach entails. Both of these requirements could be met by the same onsite survey, but it should be noted that research interviewers do not have the same powers as Ministry for Primary Industries Fishery Officers to determine whether a fisher was registered. It would be difficult and uncertain to scale catch of the registered population to the fishing population if compliance or participation was low. While routine Fishery Officer compliance operations could also check on registrations, the typically targeted nature of these activities make them less useful than a probabilistic survey as a means of monitoring participation in a representative manner.

Neither a mandatory or voluntary registry of marine recreational fishers has been implemented previously in New Zealand, but mandatory licences are a key part of the management of some recreational fisheries overseas (e.g., South Africa, parts of Australia and USA) and in fresh water in New Zealand[7]. The concept of using a marine angler registry to provide a sampling frame for a probabilistic survey has been identified as one option to improve catch and effort information for recreational fisheries for the Hauraki Gulf (Fisheries New Zealand, 2023). Widespread public support, political will and changes to regulations would be required to implement a mandatory scheme in New

[7] https://www.fishandgame.org.nz/freshwater-fishing-in-new-zealand/fishing-licences-and-regulations/general-fishing-licence-info/

Zealand. Recent stakeholder engagement (particularly in areas of South Island) suggests support may be growing for such an approach. Implementing such a change would require wide communication to explain the reasons for the new approach and help expand support.

Any registry-based approach would require the development and maintenance of a registration database.

Such a scheme would not apply to Māori Customary harvest, which is managed and reported through the Customary Permit system.

The benefits and disadvantages of voluntary and mandatory registry regimes are summarised in Table 4.

Table 4: Benefits and disadvantages of voluntary and mandatory registry regimes.

	Voluntary registry	**Mandatory registry**
Benefits	• Faster to implement than mandatory approach (no regulation change, less opposition) • No exemptions needed • Not a barrier to casual participation • Lower compliance cost	• Greater coverage if there is sufficient participation once implemented
Disadvantages	• Risk of avidity bias • Enrolment rate may not be sufficient if there is no clear incentive to participate	• Consultation process and regulatory change will take time • Additional enforcement and penalties required • Mandatory process may face some opposition from recreational sector
Both need	• An easy-to-use registration system • Sustained communication • Onsite compliance / participation survey and mean weight survey (potentially combined)	
Both provide	• A more efficient, targeted sampling frame for panel survey	

3.3 Mandatory or voluntary self-directed reporting via a mobile device application (app)

Here we consider mandatory or voluntary unprompted reporting, rather than the use of a reporting app as part of a directed survey (see comparative study described in Section 3.1.2), although some of the same issues may apply.

Catch reporting apps have been developed to collect date-, time- and location-stamped effort and catch data, offering the potential of near-real-time catch and effort monitoring (e.g., Mainland Catch app developed by Fish Mainland with support from Sustainable Food and Fibre Futures and Myers Foundation Trust - Mainland Catch App - Fish Mainland - and the Fish4All app developed by Terra Moana (withdrawn, but may be relaunched). Fisheries New Zealand has also recently introduced a mandatory electronic catch and effort reporting system for all amateur fishing charter vessel operators (Amateur Charter Vessels - eCatch for Amateur Charter Vessels). Reviews of the opportunity for using mobile phone apps in estimating recreational harvest are provided by Anon (2017) and Brick et al. (2022). A review of expert opinion concluded that *apps were unlikely to be a "stand-alone" method, at least in the short term, but could be of immediate use as a novel approach to collect supporting data such as, fisheries-specific temporal and spatial distributions of fishing effort, and*

aspects of fisher behaviour (Skov et al. 2021). Documented examples of the use of apps in estimating recreational harvest are quite limited, but Liu et al. (2017) estimated red snapper harvest in Texas using voluntarily provided data from the iSnapper app (in conjunction with validation sampling) with a CV of 68%.

The NRB's NPS extension study found substantially lower uptake rates, response rates and panellist retention rates when a self-enrol/self-report app was offered to panellists who volunteered for a further year of reporting (Heinemann et al. 2021). Such a system could be used to monitor fishery trends (tracking the data of key participants), but mandatory enforcement would be required to estimate total absolute harvests, in addition to some form of compliance estimation survey. No mandatory reporting of recreational harvest is currently required in New Zealand other than from Amateur Charter Vessels or under S.111 general approvals, although such an approach has been proposed by the Fiordland Marine Guardians and Kaikoura Marine Guardians.

User experience testing and ongoing maintenance of an app are very important considerations. While a third-party app is currently available (Mainland Catch), Fisheries New Zealand data requirements have not been defined, and so it cannot be determined as to whether this app would meet requirements. Fisheries New Zealand would require access to data collected. Furthermore, while cell phone use is thought to be high (> 90% in some regions, on basis of the census data), not all fishers use app-enabled devices, such as the smart phones, tablets or computers required to run the apps.

Onsite surveys would still be required to provide mean weight estimates and to estimate compliance / participation with the scheme. Fish lengths could be recorded on the app (and this is included in the functionality of the Mainland Catch app) although, as noted in relation to the NPS, previous studies suggest that fishers tend to overestimate the size of fish or disproportionately report larger fish (Ryan & Kilner 1994).

Mandatory app reporting is being trialled in Australia (Victoria Rock lobster reporting program - VFA and Tasmania Recreational rock lobster catch reporting | Fishing Tasmania), and the resulting comparisons with licence-based offsite harvest estimation surveys may provide useful insight into the efficacy of apps (none available to date). Preliminary results from both Victoria and Tasmania suggest that about half of all fishing activity was reported using the app in its first year (Jeavons 2023; Rickards, 2024) highlighting the need for compliance surveys and validation. The precision and accuracy of any harvest estimates provided through self-reporting would be related to the participation rate of fishers using these apps and their frequency of fishing. Participation rates would be expected to be higher for a mandatory system.

3.4 Tag ratio method

Recreational harvests can be estimated by multiplying the weight of the commercial landed catch by the ratio of recreational to commercial tag returns, when widespread tagging has occurred. This method of estimating recreational harvests has been called the "tag ratio method". To obtain a recreational harvest estimate it is necessary to use visible tags which are readily evident and returnable by recreational and commercial fishers, because widespread independent examination of recreational landings for "marked" fish is not feasible. Visible tags are already used in mark recapture studies to estimate growth in rock lobster. While tagging programs are expensive, they can also be used for other purposes such as understanding movement patterns or estimating the stock biomass (although internal tags are preferred for this to avoid potential misreporting bias).

Opportunistic tag ratio estimates of recreational harvest have been made in New Zealand, as a byproduct of snapper biomass tagging programmes conducted in the 1980s (Baird & McKoy 1988; Kirk et al. 1988). A relatively simple ratio was used in this New Zealand example, but more sophisticated analytical approaches are available (e.g., Bernard & Clark 2011).

The tag ratio method would require ongoing spatially representative tagging of large numbers of rock lobster. It would be assumed that sufficient mixing occurs for all marked fish to be equally vulnerable to the commercial and recreational sectors. A reasonably uniform tagging rate is required because the spatial distribution of commercial and recreational lobster fishing is often different.

Analysis of data from the snapper tagging programmes conducted in New Zealand during the 1980s has shown that misleading reporting behaviour may have led to an inflated recreational harvest estimate, when tag recaptures associated with commercial fishing activity were attributed to recreational fishing. For example, fishers may remove tags from discarded gravid or moulting lobsters in order to claim the reward despite the fact that the animal was not landed. Some commercial fishers may pretend to be recreational fishers to claim the reward, without affecting any biomass estimate that might be based on commercial tag return rates.

After reviewing these issues, the technical working group concluded that this was not a viable method of estimating recreational harvests and should not be considered further. It was therefore not evaluated against the criteria.

3.5 Horn tagging

A 3-year trial programme to estimate recreational harvest of rock lobster using horn tagging was started in Victoria, Australia in 2017. Participation in this programme was mandatory, requiring all rock lobster harvested by recreational fishers to be tagged before landing. Initially, tags were made of plastic, but these were replaced with digital tags in phase 2, starting in 2021. This change effectively makes the current recreational rock lobster harvest reporting in Victoria mandatory self-directed reporting via an app (Section 3.3).

For the initial 3-year trial, fishers registered to receive plastic tags (free of charge), and then reported tag use online, with the number of tags used equating to lobster numbers harvested. A lobster catch reporting app was introduced following the initial 3-year trial, where lobster catches were electronically tagged (digital tags) to avoid plastic pollution and issues of tag reuse or loss. This method is reliant on fishers reporting catches accurately, and non-reporting is less likely to be detected by any compliance / participation survey when digital tags are used instead of plastic tags.

The horn tagging approach provides estimates of harvest number, but onsite surveys are still required to provide mean weight information to convert numbers to harvest weight and to estimate compliance / participation with the scheme. An overview of the tagging programme is provided by Jeavons (2023).

The University of Tasmania (UTAS) ran a recreational phone/diary survey (as used in Tasmania) in parallel with the 2019–20 tagging season to calibrate the tagging programme and provide a comparison of the methods (McDonald et al. 2019). Absolute harvest estimates from the horn tag and diary approaches are not compared within the report, but anecdotal comments from members of the project team suggest that the number of lobsters harvested by the participants in the UTAS phone/diary survey was significantly higher than reported by the same participants when they reported their catch using the horn tagging programme app. The number of active fishers not registered with the programme was not estimated.

While recreational fishing licences have been required in Victoria for many years, horn tagging was a new concept that required fisher education. The Victorian Fisheries Authority has undertaken a state-wide initiative with Compliance Officers collecting details when conducting an inspection of recreational rock lobster fishers to enable comparisons of data reported through the app. The most recent report suggests that, in 80% of 25 rock lobster inspections, tags were accurately reported (VFA 2022). Previous reports have noted “a wide range of discrepancies” (VFA 2020). Compliance officers focused on educating fishers when the horn tagging programme was first introduced, sometimes

filling in tag reports with and for fishers. There are no quantitative data available on compliance rates. Overall numbers of lobsters harvested (as reported through the tag programme) are reported annually (e.g., VFA 2022), and appear to have declined over time. The number of participants in the Victorian recreational rock lobster tagging programme effectively halved following the switch from plastic tags in 2020, to app based digital tags in 2021 (from 5516 to 2819 fishers), and the average reported catch per participant also declined (from 0.70 to 0.55 lobsters per year), despite increasing commercial CPUE over the same period (Jeavons 2023). These estimates do not appear to take account of non-compliance, and no measures of uncertainty about the estimates are provided.

The horn tagging system applied in Victoria included a citizen science component where 11% of participants opted to provide additional information, including lobster size (VFA 2020). As noted earlier, previous studies have suggested fishers tended to overestimate the size of fish they retained when self-reporting (Ryan & Kilner 1994), and as discussed in relation to registry based surveys, onsite surveys could also be undertaken to provide mean weight estimates (required to convert numbers to harvest weight) and some form of monitoring (which could also be part of the onsite surveys) would also be required to estimate compliance.

3.6 Creel surveys

Creel surveys are an onsite approach, generally applied to specific areas of coast. The term "creel survey" historically referred to inspections of creels, which are the baskets in which recreational anglers traditionally kept their catch. Creel surveys are often referred to as boat ramp surveys in New Zealand, as most interviews have been conducted at boat access points through which most boat fishers return at the end of their fishing trip. Although most creel surveys are conducted at boat ramps, not all boats pass through boat ramps, and not all effort is boat-based. Harvesting of some shellfish species occurs mostly along the shoreline and, in these instances, it may be more appropriate for an interviewer to move along the shore, interviewing fishers as they go. Creel surveys can, therefore, take many forms, including simple access point surveys, bus route surveys, and roving-roving surveys (Pollock et al. 1994).

Creel surveys have been widely used internationally and in New Zealand for many years (e.g., Hartill et al. 2020; Holdsworth, 2022) and are familiar to multiple research providers. Being onsite surveys, they directly record information on fishing effort and catch, including fish size and bag sizes.

3.6.1 Fishery all-site creel surveys

A statistically designed survey of all potential (or as many as feasible) access points (including marinas and stretches of shoreline from which fishing or diving may take place) can be analysed as an all-site creel survey. To date, these surveys have been implemented to provide occasional total (or a high proportion of the total) harvest estimates in New Zealand, rather than as an annual monitoring programme.

Substantial survey effort is required to conduct an all-site survey and, given the difficulty in sampling all areas throughout the survey day and all fishing methods, other sources of information would generally be required to estimate the additional harvest that is not landed at surveyable access points (e.g., from NPS panellist data). Some vessels moor at sea and do not return to a point of access on the day of fishing, leading to an underestimate of the recreational harvest taken on a survey day. Previous applications of this approach to monitor recreational rock lobster fisheries in New Zealand have resulted in relatively precise estimates of harvest from the survey (12% CV in CRA 1, Holdsworth, 2014; 11–12% CV in CRA 2, Holdsworth, 2016), but the precision of the scaled estimate of QMA-wide harvest depends on the size and uncertainty of the scaling proportion provided by the absolute harvest estimate (i.e., a recent NPS survey) as well as the precision of the survey estimate. The

precision of the harvest estimates generated by these previous rock lobster surveys (scaling for unsampled fisheries) was 17% for CRA 1 and 47% for CRA 2 (Holdsworth, 2014, 2016).

Dawn and dusk surveying would be required in regions where a significant proportion of the lobster catch is taken by pot fishers, because pot fishers make short trips at these times to inspect and land their catch.

3.6.2 Relative harvest creel surveys

A relative creel survey provides a relative annual harvest index that can track changes in the harvest and can be scaled up to estimate the total harvest if a concurrent absolute harvest is available for one or more years. Relative creel sample interviewing following a consistently applied sampling design can be restricted to a subset of access points (ideally across the full spatial range of the fishery, proportional to the anticipated spatial distribution of catch), interviewing fishers over a restricted part of the day (when most lobsters are expected to be landed) and can be restricted to a peak season (when the majority of recreational harvest is usually taken). This ability to "focus" sampling effort makes relative surveys considerably less expensive and more logistically feasible than an all-site creel survey approach, but requires concurrent NPS estimates and previous survey data to inform the survey design. Again, dawn and dusk surveying would be required in regions where a significant proportion of the lobster catch is taken by lobster pot, because these are the times pot fishers tend to land their catch.

This approach has been implemented for CRA 2 (sampling the 2019–20 to 2024–25 seasons) (Maggs et al. 2024 and subsequent MAFWG presentations) and CRA 1 (sampling the 2022–23 season)(Johnson et al. 2024) and in 2024–25. While a direct scaling approach was initially applied (Hartill et al. 2022), a more comprehensive integrated modelling approach to estimating the annual harvest is under development (internal MAFWG developments and Maggs et al. 2024). Individual relative harvest surveys in CRA 2 have previously had CVs between 22 and 48% (Maggs et al. 2024), estimated on the basis of monitoring at six boat ramps from the Hauraki Gulf and Bay of Plenty. The precision of any annual estimate generated from a relative survey will be partly determined by the precision of the absolute or other relative estimates it is scaled to. Scaling approaches are still being developed, but more recent analysis incorporating standardisation of the catch numbers series using wind speed data has generated annual harvest estimates with a CV around 20% for CRA 2 from these surveys, with improved precision if the estimate is considered as an average over a series of years. A previous creel survey (only sampling the Coromandel coast) produced harvest estimates with a CV of 21% (Holdsworth & Walshe 2014).

4. Other possible methods

In addition to the methods described above, which were considered to have the most merit, a range of other approaches were considered by Twiname et al. (2022). These and other potential methods considered through MAFWG discussions are listed in Table 5, but have not been considered for evaluation because of the key limitations identified.

Table 5: Other rock lobster recreational harvest estimation approaches identified, but not considered in detail, and key limitations of the approach.

Harvest estimation approach	Key limitation
Lobster pot registration and reporting	Does not cover snorkel or diver catch, which can be a major component in northern New Zealand fisheries (see Appendix 1).
Scuba tank fill registry	Does not cover free dive or pot fishery. Some divers / vessels have private compressors. There may be a considerable delay between a tank fill and use (fishing).
Aerial surveys	Can only address effort, and snorkellers and divers are very difficult to observe from the air. Requires a creel survey to estimate catch per trip.
Video monitoring access points	Only provides partial measure of effort for specific access points, and no information on methods or harvest.
Parking snapshot surveys	Only provides partial measure of effort for specific access points, and no information on methods or harvest.
Telephone diary surveys	Early harvest estimates in New Zealand used telephone recruitment of fishers, but a number of biases were identified that led to the development of the NPS. Telephone diary surveys are no longer considered reliable.
Catch cards	Similar to horn tagging: self-directed method of reporting as part of another system. This is a data collection tool rather than a type of survey design.
Telephone reporting	Overlap with some of the methods reviewed here, but only a partial solution with contactability issues. This is a data collection tool rather than a type of survey design.

5. Overview of key potential approaches

The management preference is for regular estimates of recreational rock lobster harvest (in tonnes) that can be used to track changes and account for the harvest taken by the recreational sector over time, recognising the fluctuating nature of that catch. The main approaches described above could all be used (individually, or in combination) to provide an annual harvest estimate. However, none of the approaches in themselves provide all the information required to generate absolute harvest estimates over a series of years. The fishery metrics provided by each approach and the additional sources of information that are required to derive absolute harvest estimates from these surveys are summarised in Table 6.

Table 6: Summary of survey method outputs provided by survey type and additional requirements.

	Provides			Also required		
	Absolute harvest	Bag size	Lobster size	Absolute harvest	Mean weight	Onsite compliance/ participation survey
NPS (and variants)	✓	✓	–		✓	–
Creel (all-site)	✓	✓	✓	?*	–	–
Creel (relative)	–	✓	✓	✓	–	–
CATI with registry sampling frame	✓	✓	–	–	✓	✓
Horn tagging	✓	✓	–	–	✓	✓
Reporting app	✓	✓	–	–	✓	✓

*- while an all-site creel survey samples all (or as many as feasible) access points, there may still be a requirement to account for unsampled areas/methods, requiring a knowledge of what proportion of the fishery has been sampled. Any scaling for an all-site creel approach would be less than for a relative creel survey.

6. EVALUATION OF ALTERNATIVE SURVEY APPROACHES

The technical working group considered the list in Table 6 to include all the most promising approaches. The next step was to agree on a set of criteria that could be used to evaluate the relative viability of each method, and a broad range of criteria were identified and defined. These criteria were used to assess each survey approach in terms of logistical requirements, potential bias, public acceptability, a demonstrated track record of successful application, fishery coverage and the broader utility of the information they might provide. A more descriptive list of these evaluation criteria is given in Appendix 2.

The technical working group members were then asked to independently score each method against the agreed evaluation criteria, to inform an objective ranking of alternative approaches, given the range of experience and perspectives provided by all concerned. A subset of working group members also estimated cost for some survey method components but given the difficulties in generating comparable costs across approaches, these were not used in scoring. The various logistical requirements of each approach were identified. The working group then met to discuss and compare their respective criteria scores. Consensus scores and the average and range of individual scores for each survey method are given in Table 7. In some instances, these discussions highlighted differences in the interpretation of how a survey might be implemented, or how a criterion should be interpreted, which were resolved by consensus.

The relative ranking of the different approaches were compared on the basis of individual criteria (Table 8), and also using utility scores of increasing complexity including reliability of estimates (considering both bias and precision), whether an approach was “tried and tested”, coverage of the fishery and likely public support (Table 9). Rankings are compared on the basis of consensus scores, although the patterns on the basis of average scores were very similar (Appendix 3). Both additive and multiplicative utility functions were explored, giving each criterion equal weighting. It is acknowledged that fishery managers may give more weight to some criteria. The rankings generated by the different utility functions varied slightly depending on the components included (discussed in more detail below) but generally the NPS, the two types of creel surveys and mandatory registry-based approaches scored higher, while the horn tagging voluntary registry and reporting app approaches consistently scored lower.

Table 7: Consensus scores, the average of individual scores (and the range of individual scores in parenthesis) for evaluation criteria scoring of alternative survey approaches that could be used to estimate recreational harvests taken from all rock lobster stocks (National) or from a single stock only (such as CRA 2). Lower numerical scores (range: 1 to 5) indicate more favourable assessments for a given criterion. Additional descriptor information for the evaluation criteria is given in Appendix 1. A summary of method outputs and requirements is also given in Table 6.

Evaluation criteria	National Panel Survey (3 yearly)	Fishery all-site creel survey	Relative harvest creel survey	Panel survey with a voluntary registry sample frame	Panel survey with a mandatory registry sample frame	Mandatory horn tagging	Mandatory reporting app	Voluntary reporting app
Spatial extent considered	National	CRA 2	CRA 2	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)
Compliance and participation survey dependency (Y/N)	N	N	N	Y	Y	Y	Y	Y
Reliability (bias & precision)	2.5, 2.1 (1–4)	2, 1.7 (1–3)	2.5, 2 (1–3)	3.5, 2.8 (1–4)	2.5, 2.3 (1–4)	4, 3.1 (2–4)	3.3, 3.3 (2–4)	5, 4.7 (3–5)
Likely precision (how precise are estimates likely to be)	3.5, 3.5 (3–4)	3.5, 2.6 (2–4)	3, 2.7 (2–4)	3, 2.3 (1–4)	2, 1.8 (1–3)	4.5, 2.7 (2–4)	2.9, 2.9 (2–4)	4.5, 3.9 (3–5)
Likely public support (problems of non-compliance)	2, 1.6 (1–2.5)	1, 1.3 (1–2)	1, 1.3 (1–2)	3, 2.6 (2–4)	5, 4.1 (3–5)	4, 3.6 (3–5)	3.6, 3.6 (3–4.5)	2, 2.7 (2–4)
Tried and tested method (demonstrated successfully?)	2, 1.6 (1–2.5)	2, 2.2 (1–4)	2.5, 1.8 (1–3)	4.5, 4.2 (3–5)	3.5, 3.4 (2–5)	4, 4.1 (3–5)	4.4, 4.4 (4–5)	5, 4.3 (3–5)
Coverage of entire fishery (are all fishing methods sampled?)	2, 1.9 (1–4)	2.5, 2.7 (2–4)	3.5, 3.4 (2–4)	2, 1.6 (1–3)	1.5, 1.4 (1–3)	2, 1.9 (1–4)	1.8, 1.8 (1–3)	2, 3 (1–5)
Links to other species (does the method provide estimates for other species?)	Y	Y	Y	Y	Y	Y	Y	Y
Management regime changes required (Y/N)	N	N	N	N	Y	Y	Y	N

Table 8: Ranking of consensus criteria scores of alternative survey approaches that could be used to estimate recreational harvests taken from all rock lobster stocks (National) or from a single stock only (such as CRA 2). Lower numerical scores indicate more favourable ranking.

Evaluation criteria	National Panel Survey (3 yearly)	Fishery all-site creel survey	Relative harvest creel survey	Panel survey with a voluntary registry sample frame	Panel survey with a mandatory registry sample frame	Mandatory horn tagging	Mandatory reporting app	Voluntary reporting app
Spatial extent considered	National	CRA 2	CRA 2	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)
Reliability (bias & precision)	2	1	2	6	2	7	5	8
Likely precision (how precise are estimates likely to be)	5	5	3	3	1	7	2	7
Likely public support (problems of non-compliance)	3	1	1	5	8	7	6	3
Tried and tested method (demonstrated successfully?)	1	1	3	7	4	5	6	8
Coverage of entire fishery (are all fishing methods sampled?)	3	7	8	3	1	3	2	3
Average rank	2.8	3	3.4	4.8	3.2	5.8	4.2	5.8

Table 9: Ranking of various utility scores from consensus criteria scores of alternative survey approaches that could be used to estimate recreational harvests taken from all rock lobster stocks (National) or from a single stock only (such as CRA 2). Lower numerical scores indicate more favourable ranking.

Evaluation criteria	National Panel Survey (3 yearly)	Fishery all-site creel survey	Relative harvest creel survey	Panel survey with a voluntary registry sample frame	Panel survey with a mandatory registry sample frame	Mandatory horn tagging	Mandatory reporting app	Voluntary reporting app
Spatial extent considered	National	CRA 2	CRA 2	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)
Reliability + Precision	4	2	2	6	1	7	5	8
Reliability + Precision + Tried and tested	2	1	2	6	2	7	5	8
Reliability + Precision + Tried and tested + Coverage	2	2	4	6	1	7	5	8
Reliability + Precision + Tried and tested + Coverage + Support	2	1	3	6	4	7	5	7
Reliability × Precision	4	2	3	6	1	7	5	8
Reliability × Precision × Tried and tested	2	1	4	6	2	7	5	8
Reliability × Precision × Tried and tested × Coverage	2	2	4	6	1	7	5	8
Reliability × Precision × Tried and tested × Coverage × Support	3	1	2	6	4	8	5	7

6.1 Fishery all-site creel survey method evaluation

The fishery all-site creel survey approach has been used to estimate rock lobster harvest in CRA 1 and CRA 2 (Holdsworth 2014, 2016). The method ranked highly in terms of the reliability, public support and "tried and tested" criteria. The data collection protocols associated with this method have been extensively tested and demonstrated to provide precise harvest estimates for the surveyed component of the fishery, and on the basis of previous experience a high degree of public cooperation is considered likely. The method was ranked lower for precision of the total harvest estimate and poorly for coverage of the entire fishery. Data and estimates from a concurrent or recent NPS are still required to account for catches taken from the shore and in parts of the QMA outside the survey area. The precision of the total harvest estimate will be influenced by the precision of the NPS estimate. The poor coverage score relates to the fact that this method is not suitable for estimating harvests caught using rock lobster pots because fishers usually lift and check their pots very early in the day or late in the evening and are, therefore, rarely encountered during creel survey hours. This means that this method is only considered viable for the CRA 1 and CRA 2 recreational rock lobster fisheries, where almost all of the catch is taken by SCUBA or free divers (<5% harvested by pot in CRA 1 and CRA 2, compared with 25–50% for some other stocks; Heinemann & Gray 2024). A breakdown of estimated rock lobster recreational harvest by method is provide for each stock for each of the NPSs is provided in Appendix 1.

The fishery all-site creel survey approach ranked highly across all the utility scores.

This method is logistically demanding and relatively expensive because of the high level of spatial and temporal coverage required for a 12-month survey. The technical working group considered fishery all-site creel surveying to be the most viable method for assessing the short-term, recreational, boat-based diver harvest taken in the most commonly fished areas of CRA 1 and CRA 2. Onsite data collection includes catch numbers, size and sex, and fishing effort recorded with short recall time and direct observation by trained interviewers. High labour costs determine how many survey days per year can be sampled and how frequently the annual survey can be repeated. The method would not be suitable for other CRA stocks (given the proportion of the recreational harvest taken by pot) and it seems unlikely that surveys could be funded on a regular basis.

6.2 Relative harvest creel survey method evaluation

The relative harvest creel survey approach has been used to monitor recreational harvests taken from CRA 1 and CRA 2 (Johnson et al. 2024; Maggs et al. 2024). The method ranked highly in terms of reliability and public support, and relatively highly in terms of the likely precision and "tried and tested" criteria. While based on the same sampling process as the all-site approach, consensus discussions resulted in this method scoring slightly higher that the all-site approach as multiple annual estimates would improve the precision of an average value. As with the all-site approach, this method is also based on established creel survey methods, and it is considered that a high degree of public cooperation is likely. Although the data collection methods have been extensively tried and tested, the analytical methods used to derive harvest estimates and estimates of precision have yet to be finalised, although existing estimates are thought to be acceptable and have been considered to be absolute estimates for the recent stock assessment in CRA 2 (Pons et al. 2025; Rudd et al. in prep). Initial analyses suggest that it would be possible to monitor long terms trends in absolute harvest within CRA 2 if concurrent NPS total harvest estimates are available for some of the surveyed years (Figure 1). Analytical method development may lead to a revised sampling design for this type of survey.

The method was ranked poorly for coverage of the entire fishery. As with the all-site creel survey this relates to poor sampling of pot-based fishing. This means that this method is only considered viable for the CRA 1 and CRA 2 recreational rock lobster fisheries, where almost all of the catch is taken by SCUBA or free divers (<5% harvested by pot in CRA 1 and CRA 2, compared with 25–50% for some other stocks; Heinemann & Gray, 2024). A breakdown of estimated rock lobster recreational harvest by method is provided for each stock for each of the NPSs in Appendix 1.

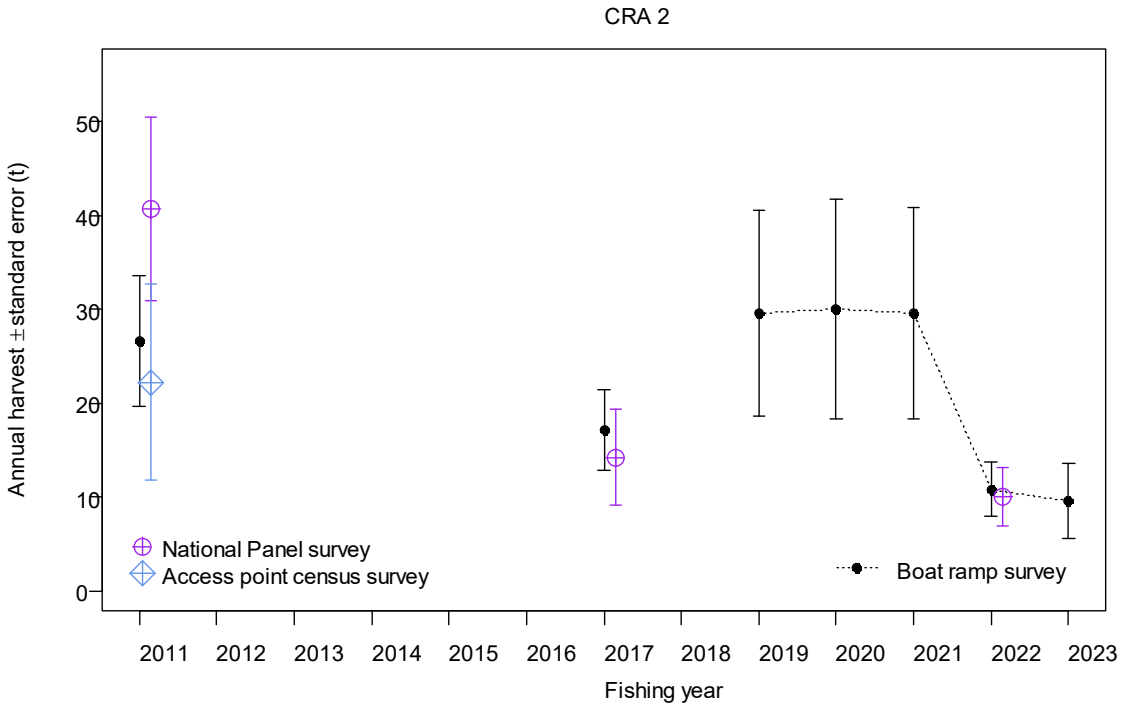

Figure 1: Comparisons of trends seen in NPS estimates with those derived from scaled independent boat ramp surveys designed to monitor trends in recreational harvesting from CRA 2 (Maggs et al. 2024).

The relative harvest creel survey approach ranked highly for the utility scores, which additively combined the reliability, precision and "tried and tested" criteria, but ranking reduced with the inclusion of coverage in the utility function. The high public support score increased the utility when this was included. While the multiplicative utility scores showed the same general pattern as the

additive ones, the relative ranking for this survey method was more sensitive to the choice of additive or multiplicative function than any of the others considered.

This type of relative creel survey approach is substantially cheaper than the all-site creel survey approach because it is necessary to sample only a few spatially representative high-traffic boat ramps during the months and times of day when most rock lobster harvest is landed, collecting data on catch numbers, size and sex, and fishing effort. Longer-term, multi-year monitoring of recreational harvesting levels is, therefore, more cost-effective with this method. The precision of estimates provided by this approach will be lower than those obtained by an all-site type creel survey because there is a greater reliance on data provided by concurrent NPSs to scale up the relative harvest index. The precision and potential accuracy of such a scaled harvest index should improve when the creel survey data are scaled to NPS estimates from multiple years.

Although the relative harvest creel survey was ranked lower for utility than the all-site survey by the technical working group, the much lower cost of this approach probably makes it a more viable and cost-effective means of monitoring multi-year trends in recreational harvesting taken from a stock where most of that harvest is taken by boat-based divers (i.e. CRA 1 and CRA 2).

6.3 National Panel Survey method evaluation

The NPS was first completed in 2011–12 (Wynne-Jones et al. 2014) and repeated in 2017–18 (Wynne-Jones et al. 2019) and 2022–23 (Heinemann & Gray 2024). The method is based on rigorously designed probabilistic sampling methods that have produced harvest estimates for some finfish species, which were corroborated by fully independent survey methods in 2011–12 (Hartill & Edwards 2015) and 2017–18 (Hartill & Bian 2020). It is, therefore, a reliable and tried and tested method (scoring highly for these criteria) that potentially provides good coverage of all aspects of recreational harvesting by New Zealand residents. The approach received intermediate scores for likely public support and coverage of the entire fishery, and a relatively poor score for precision when used to estimate rock lobster harvest. Previous surveys have had good levels of participation, but drop-out rates increased markedly in the 2022–23 survey (potentially associated with the easy opt-out "STOP" option for text communication that was required by the telephone service provider). The main limitation with this approach is that the precision of estimates is largely determined by the number of panellists participating in a fishery. Only a relatively small percentage of fishers gather rock lobster in New Zealand (about 8% of active panellists within NPSs), and a random sample of ~6000 to ~7000 panellists recruited by a ~30 000 dwelling screening survey is unlikely to include enough active rock lobster fishers to inform reasonably precise recreational harvest estimates for most rock lobster stocks. While reasonably precise harvest estimates (CV < 25%) have been obtained for some of the more frequently fished rock lobster stocks in past surveys (Table 3), precision has generally been poorer than this.

The NPS received an intermediate ranking for utility scores combining reliability and precision (related to the lower precision score), but utility scores improved with the inclusion of other criteria. A similar pattern was shown by both additive and multiplicative utility scores.

There are two potential improvements that could be made to a future NPS survey design to boost the number of survey participants who are rock lobster fishers. The first would be to ensure that all rock lobster fishers identified during initial household screening are invited to participate in the following 12-month panel survey. In the current screening survey design, only one fisher is selected at random from a fishing household and invited to be a panellist, regardless of their fishing avidity and the type of fishing they claim to undertake. While the initial random selection of one fisher from each fishing household should be maintained to ensure the integrity of the current probabilistic NPS sampling design, other unselected fishers in the household who claim to be rock lobster fishers could also be recruited into an auxiliary panel. Probabilistic sampling weights could still be calculated for these additional panellists. The expected gain in estimate precision achieved by empanelling these

additional fishers would be reduced if the rock lobster harvesting of multiple fishers in the household is statistically correlated. The wash-up survey (a post fishing season online questionnaire collecting additional information from panellists on their fishing and survey experience through the year) for the 2022–23 NPS (Heinemann 2024) included a question about how many other inhabitants in a panellist's household harvested rock lobster, to gauge the number of additional rock lobster fishers that might be empanelled if this targeted additional sampling approach were to be adopted. Only a small proportion (4%) of households contained an additional fisher who had fished rock lobster in the previous 12 months, suggesting that additional screening for rock lobster fishers within the panel recruitment process wouldn't compromise the overall estimates, while potentially recruiting additional valuable rock lobster fishers (potentially doubling the number of rock lobster fishers).

The second improvement would be to invite any panellists in the 2022–23 NPS who caught rock lobster to be re-empanelled in the next NPS. The probabilistic sampling weights calculated for these panellists in 2022–23 could be adjusted in the future based on up-to-date national census data at the time. This recalculation of sampling weights would have to take into account both recruitment into the age 15+ panellist cohort and deaths, but approximated sampling weights would probably still be reasonably accurate (Alistair Gray NPS Statistician, Statistics Research Associates LTD, pers. comm.). It may be difficult to make contact with many of the panellists who agree to participate in the next NPS, however, as between-dwelling mobility in New Zealand is high by international standards. This may be less of an issue, given the increased incidence of cell phone ownership in recent years, and the high reliance on cell phones as the main contact mechanism of panellists. Regardless, experience from the 2017–18 extension survey suggest that panellist attrition rates can be high when they are asked to report their catch and effort for more than a year. This option is only possible if panellists are asked during their time on a panel if they would like to be re-empanelled for a future NPS, because ethics rules prohibit recontacting survey participants after they have left a survey that they agreed to participate in for a specified time period. Within the wash-up survey for the 2022–23 NPS, panellists were asked if they were happy to be contacted for further research about their recreational fishing. Of over 2000 respondents to the wash-up survey (40% of the original panel), 68% confirmed they would be happy to be contacted in the future.

Although the cost of a single NPS is high, this cost should be considered alongside its ability to estimate recreational harvests for all of New Zealand's substantive recreational fisheries, for both finfish and shellfish. If one or both of the rock lobster panellist boosting methods is successful (they could also be considered for paua [abalone] fisheries), then the NPS method might provide more precise estimates for most of New Zealand's rock lobster stocks. The main drawback with an adapted NPS survey is that these surveys are only conducted every 5 to 6 years because of their high cost. Recreational harvest levels can fluctuate substantially between years, in response to prevailing weather conditions, fishing rules and fish abundance, and a higher sampling frequency is desirable for both rock lobster and other fisheries. The cost-effectiveness of any survey method should, therefore, be considered in terms of annual averaged costs. Conducting a NPS survey more frequently (with potential improvements identified above) could lessen the need to conduct other smaller surveys that are currently conducted in the intervening years between NPS surveys, such as the current CRA 2 monitoring programme, acknowledging that this would still not provide annual estimates. Fish size is not currently reported by panellists, and additional onsite sampling (through regular creel monitoring) would be required to provide a mean weight to scale harvest numbers to harvest weight.

6.4 Mandatory registry sample frame panel survey method evaluation

A panel survey based on a mandatory rock lobster registry sample frame could be used to estimate recreational harvests in a more targeted and cost-effective manner than the current NPS survey. A dedicated, mandatory rock lobster registry would negate the need for a national household screening survey and would allow easy and cost-effective recruitment of enough rock lobster fishing panellists for precise estimates for all stocks. A mandatory registry for recreational fishers has not previously been implemented in New Zealand, but a similar approach (using a license holder registry as an off-

site survey sample frame) has been used successfully in Tasmania to estimate rock lobster and abalone harvest (Lyle et al. 2021).

This was the highest scoring method in terms of coverage (because all non-exempt rock lobster fishers would be required to register, regardless of method or location) and likely precision (based on the Tasmanian experience), and also scored highly for reliability, assuming good compliance with the registry regime. However, the approach received an intermediate score for being tried and tested (as while it has been implemented elsewhere, it has not been used previously in New Zealand), and a poor score for likely public support. Previous proposals for fisher registries have experienced resistance, which may impact compliance with such a scheme, although views may be changing, as some recreational fisher groups (particularly in South Island) have expressed a desire for a greater involvement in the provision of recreational harvest data.

The panel survey based on a mandatory rock lobster registry sample frame ranked highly across utility scores based on reliability, precision, tried and tested and coverage, but the ranking fell to an intermediate level when likely public support was included.

This survey approach offers a number of advantages in terms of reduced cost and increased precision over the existing approaches providing an absolute harvest estimate, but would be reliant on a well-estimated and high level of compliance with the mandatory registration. Some form of monitoring of compliance with the scheme would be required (to determine any scaling required of harvest from compliant fishers), and this may need to be done by Fishery Officers (because of their inspection powers). The targeted nature of existing compliance activities may mean that these would need to be expanded (at least in the first few years) to provide more representative coverage.

It seems unlikely that fish size would be reliably reported, and additional onsite sampling (through regular creel monitoring or similar) would be required to provide a mean weight to scale harvest numbers to harvest weight. This approach would also require the development and maintenance of a registry database. The technical working group did not include the expertise to determine what would be involved in this, but MPI does maintain similar systems.

6.5 Voluntary registry sample frame survey method evaluation

A panel survey based on a voluntary registry sample frame could be used in the same way as the mandatory registry discussed above but was considered by the technical working group to be generally less viable. While the voluntary approach was considered to have a higher score in relation to likely public support (an intermediate rather than a poor score for the mandatory approach), the voluntary nature of the system was considered to introduce a number of disadvantages. Fewer rock lobster fishers are likely to register voluntarily, and it was also considered that those fishers that did register would be less likely to be representative of the wider rock lobster fishing community than those who would comply with a mandatory and enforced system. This resulted in intermediate scores for coverage of the fishery and likely precision and reliability, and a poor score for tried and tested. The authors are not aware of any harvest estimation studies based on a voluntary registry sample frame.

The panel survey based on a voluntary rock lobster registry sample frame consistently ranked at the lower end of the intermediate utility scores.

Given the lower anticipated participation rates in a voluntary system, some form of continued onsite survey would be essential to try to estimate the level and representativeness of the participation. As with the mandatory registry-based approach above, additional onsite sampling (through regular creel monitoring) would also be required to provide a mean weight to scale harvest numbers to harvest weight. The mean weight and participation sampling could be combined, although without inspection powers some fishers may refuse to be interviewed. This survey method would also require the

development and maintenance of a registry database. The technical working group did not include the expertise to determine what would be involved in this, but MPI does maintain similar systems.

6.6 Mandatory horn tagging programme method evaluation

A mandatory horn tagging approach to estimating recreational harvest of rock lobsters was implemented in Victoria, Australia between 2017 and 2021 (Jeavons 2023; McDonald et al. 2019) before it was replaced by a mandatory self-directed reporting scheme via an app. The approach scored moderately for the coverage and "tried and tested" criteria, but poorly for reliability, likely precision and likely public support (given anticipated resistance to any of the mandatory approaches considered). The relatively low scores may be partially attributed to the shortcomings of the implementation in Victoria (McDonald et al. 2019), but significant challenges were also identified relating to confirming whether issued tags that were associated with a lobster at the time it was landed had actually been reported back to the issuing agency.

The mandatory horn tagging approach consistently ranked poorly across the utility scores.

Given the Victorian experience, an extensive compliance survey would be required to assess compliance rates and other sources of bias. Onsite sampling would also be required to estimate mean weight, as would some form of tag issuing/reporting system.

6.7 Mandatory app data collection method evaluation

Mandatory recreational harvest reporting app systems have recently been introduced in both Victoria and Tasmania, Australia (Jeavons 2023; Rickards 2024). Given that these systems are relatively new, the approximate 50% participation rates are not considered representative of an established system, and there has been limited opportunity to compare harvest estimates with other concurrent surveys. More detailed comparison with licence-based offsite harvest estimation surveys in Tasmania may provide insight into the viability of the mandatory app approach once it becomes more established. The approach scored highly for likely precision and coverage (on the assumption that participation would be high for a mandatory system), but received intermediate scores for the reliability, likely public support and "tried and tested" criteria.

The mandatory app approach consistently ranked at an intermediate level across the utility scores.

A key requirement would be the development and testing of a reporting app. Electronic reporting approaches have been developed in New Zealand for both voluntary (e.g., Mainland Catch app) and mandatory (e.g., the eCatch ACV app) reporting of recreational fishing activity, although it is not clear if these would be suitable in their current form or require further development. Given the initial Australian experience, a compliance survey would be required to assess compliance rates and other sources of bias. Onsite sampling would probably also be required to estimate mean weight.

6.8 Voluntary app data collection method evaluation

Examples of the use of voluntary apps in estimating recreational harvest are limited, but where use has been documented the levels of precision reported has been low (Liu et al. 2017). Relevant reviews have suggested that while voluntary apps could provide a useful component of a harvest estimation system, they are less likely to be useful as stand-alone tools for self-directed reporting (Anon 2017; Brick et al. 2022; Skov et al. 2021). The approach scored moderately for coverage and likely public support, but poorly for the reliability, likely precision and "tried and tested" criteria.

The voluntary app reporting approach consistently ranked poorly across the utility scores.

A voluntary app approach would have the same logistical requirements as a mandatory system, but a bigger challenge with this method would be understanding and accounting for the level of consistency and representativeness of reported fishing activity in relation to unreported activity. Voluntary participation rates are likely to be lower and decline over time, and extensive participation surveys would be required (although being a voluntary system this would not require Fishery Officer inspection powers). Onsite sampling would probably also be required to estimate mean weight.

While this approach could be used to collect CPUE-style abundance proxy data from consistently-reporting fishers, it could only ever provide a minimum harvest estimate (the sum of harvest reported); significant additional monitoring would be required to provide information on how to scale that estimate to a total estimate. An app could form part of a harvest reporting system (e.g., survey panellists using an app to report data), although studies have shown prompted reporting through CATI to be more reliable (Heinemann et al. 2021).

7. SUMMARY

This review was undertaken to explore potential approaches to provide annual estimates of recreational rock lobster harvest, focussing primarily on CRA 1 and CRA 2, but also considering relevance to other CRA stocks. Annual harvest estimates are currently being provided for CRA 2 through a combination of absolute harvest estimates from the National Panel Survey (every 5 or 6 years) and an annual relative harvest creel survey to interpolate harvest between absolute estimates. An alternative harvest estimation process could follow this model (ongoing relative monitoring with less frequent absolute estimates) or undertake surveys providing absolute estimates on an annual basis.

A range of rock lobster recreational harvest estimation approaches were explored and scored against criteria agreed by a technical working group made up of members of the MAFWG with experience of estimating recreational harvests and covering both commercial and recreational perspectives. Consensus and average scores were reasonably consistent, and the ranking of alternative approaches was relatively insensitive to the utility function applied across these criteria.

The methods considered most viable for providing an annual estimate of recreational harvest for CRA 1 and CRA 2 by the technical working group were an improved National Panel Survey (increasing the numbers of CRA fisher panellists) or a mandatory registry sample frame panel survey to provide absolute estimates of harvest, supported by relative harvest creel surveys to provide relative harvest between absolute estimates.

A fishery all-site creel survey also ranked highly for the northern fisheries and would provide a robust one-off survey, but if ongoing monitoring and annual harvest estimates are preferred (which they would be in most management situations), then a cheaper, relative harvest creel survey conducted in conjunction with a reasonably frequent absolute harvest estimate was considered a better option.

Both creel survey approaches were considered far less suitable for monitoring CRA fisheries with significant recreational pot fishing (CRA 3, 4, 5, 8 and 9, where between 20–50% of recreational harvest is taken by pot; minimal recreational harvest has been estimated from CRA 7) because of the poorer coverage of this aspect of the fishery. Unless an alternative relative harvest monitoring approach was identified (more suitable for pot fishing), annual absolute harvest surveys would be required if annual estimates were required. A mandatory registry sample frame panel survey was considered the most viable annual survey approach.

Mandatory or voluntary self-directed app reporting, a voluntary registry sample frame panel survey and mandatory horn tagging were all considered less viable approaches (with a mandatory reporting

app scoring highest out of these). Concerns largely related to difficulties in scaling reported harvest to all fishers (precision and bias), lack of public support, and lack of successful demonstration elsewhere (tried and tested).

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APPENDIX 1 – Recreational harvest breakdown by method

		Harvest by method (t)			
QMA	**Survey**	**Hand**	**Pot**	**Total harvest (t)**	**% Hand**
CRA1	2011–12	18.76	4.42	23.18	81%
	2017–18	15	0.31	15.31	98%
	2022–23	7.65	0.35	8	96%
CRA2	2011–12	33.8	6.33	40.13	84%
	2017–18	13.44	0.77	14.21	95%
	2022–23	9.93	0.06	9.99	99%
CRA3	2011–12	3.92	3.86	7.78	50%
	2017–18	3.78	8.43	12.21	31%
	2022–23	2.86	2.88	5.74	50%
CRA4	2011–12	29.39	13.13	42.52	69%
	2017–18	31.1	10.11	41.21	75%
	2022–23	23.68	8.9	32.58	73%
CRA5	2011–12	27.97	12.26	40.23	70%
	2017–18	24.9	15.18	40.08	62%
	2022–23	23.93	14.66	38.59	62%
CRA7	2011–12	0.23		0.23	100%
	2017–18	0.09		0.09	100%
	2022–23	1.41		1.41	100%
CRA8	2011–12	4.7	1.34	6.04	78%
	2017–18	7.34	7.32	14.66	50%
	2022–23	7.4	3.04	10.44	71%
CRA9	2011–12	13.56	4.08	17.64	77%
	2017–18	13.54	3.53	17.07	79%
	2022–23	2.55	1.95	4.5	57%

APPENDIX 2 - Evaluation Criteria

Logistic requirements (what specifics and $ estimate if possible)

- Would the proposed approach require other MPI support for ongoing implementation? E.g., Registration system setup and ongoing database maintenance?
- Input from relevant groups with permanent staff support required? Initial, ongoing?

What extra surveys are needed

- Such as mean weight surveys or compliance/participation surveys
- Are concurrent surveys required at the same annual frequency as the main survey (Annual average cost over the cycle period)

Compliance and participation survey dependency (Y/N)

- Does the proposed approach have a significant compliance or participation requirement that would be key to successful implementation? What would these be?
- Degree of input from Compliance Team required? Initial, ongoing?

Reliability (score 1–5, good to bad)

- Bias – anticipated bias
- Unmeasurable uncertainties
- Will the estimates be precise enough

Likely Precision (score 1–5, good to bad)

- Precise enough (measurable uncertainties) to inform management
- Predictability – Informed by previous experience or assumed? (how confident are we about this precision)

Likely public support (score 1–5, good to bad)

- Communication costs, potential areas of concern.
- Significant level of deliberate non-compliance

Tried and tested method (score 1–5, good to bad)

- Is the proposed approach one that has been demonstrated successfully elsewhere (in New Zealand or internationally)?

Coverage of entire fishery (score 1–5, good to bad)

- Contact method – how/where are fishers contacted
- All fishing methods – are some methods not sampled and is their likely harvest significant?
- Spatial/temporal?
- Sampling frame gaps?

Links to other species (Y/N)

- While the focus here is specifically on improving CRA recreational harvest estimates, other "specialist" fisheries may also benefit from consideration of different harvest estimation approaches. Would the proposed approach be applicable to other species, and which ones?

Management regime changes required (Y/N)

- Would the proposed approach require changes to fisheries regulations, such as the introduction of a licence or mandatory reporting?
- Does the proposed approach require changes to recreational fishing rights or regulations?
- Is input from Policy Team with significant FTE required and potential timelines.

Additional comments on known issues / considerations

- Any further comments related to the particular method

APPENDIX 3 – Ranking and utility scores based on average criteria scores

Ranking of average criteria scores of alternative survey approaches that could be used to estimate recreational harvests taken from all rock lobster stocks (National) or from a single stock only (such as CRA 2). Lower numerical scores indicate more favourable ranking.

	Survey approach							
Evaluation criteria	National Panel Survey (3 yearly)	Fishery all-site creel survey	Relative harvest creel survey	Panel survey with a voluntary registry sample frame	Panel survey with a mandatory registry sample frame	Mandatory horn tagging	Mandatory reporting app	Voluntary reporting app
Spatial extent considered	National	CRA 2	CRA 2	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)
Reliability (bias & precision)	3	1	2	5	4	6	7	8
Likely precision (how precise are estimates likely to be)	7	3	4	2	1	4	6	8
Likely public support (problems of non-compliance)	3	1	1	4	8	7	6	5
Tried and tested method (demonstrated successfully?)	1	3	2	6	4	5	8	7
Coverage of entire fishery (are all fishing methods sampled?)	4	6	8	2	1	4	3	7
Average rank	3.6	2.8	3.4	3.8	3.6	5.2	6	7

Ranking of various utility scores from average criteria scores of alternative survey approaches that could be used to estimate recreational harvests taken from all rock lobster stocks (National) or from a single stock only (such as CRA 2). Lower numerical scores indicate more favourable ranking.

	Survey approach							
Evaluation criteria	National Panel Survey (3 yearly)	Fishery all-site creel survey	Relative harvest creel survey	Panel survey with a voluntary registry sample frame	Panel survey with a mandatory registry sample frame	Mandatory horn tagging	Mandatory reporting app	Voluntary reporting app
Spatial extent considered	National	CRA 2	CRA 2	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)	National (& CRA 2)
Reliability + Precision	5	2	3	4	1	6	7	8
Reliability + Precision + Tried and tested	3	1	2	5	4	6	7	8
Reliability + Precision + Tried and tested + Coverage	2	3	4	5	1	6	7	8
Reliability + Precision + Tried and tested + Coverage + Support	2	1	3	5	4	6	7	8
Reliability × Precision	5	2	3	4	1	6	7	8
Reliability × Precision × Tried and tested	3	1	2	5	4	6	7	8
Reliability × Precision × Tried and tested × Coverage	2	3	4	5	1	6	7	8
Reliability × Precision × Tried and tested × Coverage × Support	2	1	3	5	4	6	7	8