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Estimating recreational harvests of rock lobster

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EXECUTIVE SUMMARY

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Recreational fishers account for a substantial proportion of removals from many, if not all, of New Zealand's rock lobster stocks. Reliable estimates of the recreational harvest are, therefore, required for the assessment and management of lobster fisheries, yet they remain elusive. Unfortunately, of all the species targeted by recreational fishers, rock lobster harvests are among the hardest to estimate. This is partially because the methods employed in these fisheries are diverse, specialised, and used only by a small sector of the fishing community.

It is preferable, therefore, that any harvest estimation method should be designed with the nature of the recreational rock lobster fishery specifically in mind. This report reviews a range of approaches which could be employed, either individually or in unison, to provide harvest estimates of varying reliability. Each approach is outlined in broad terms, and pitfalls and assumptions are discussed.

Many survey techniques employ some form of creel survey, where a fisher's catch and effort is recorded during an interview, usually at the end of a fishing trip. Creel surveys can be employed solely, to estimate the entire harvest, when all access points are covered, or as part of a larger survey which has other methodological components. In the latter case, creel surveys have been used in conjunction with telephone/diary surveys, or more recently, as part of aerial overflight surveys. It is not cost effective to solely use creel surveys for fisheries over large spatial scales, as the number of potential access points is high, yet the incidence of lobster landings at each point is usually low.

Recreational harvests are sometimes derived incidentally from tagging programmes. The ratio of recreational to commercial tag returns is combined with a known commercial catch tonnage for the same period, providing an estimate of the recreational harvest. Experience with other species suggests that misleading fisher reporting behaviour often leads to positively biased harvest estimates. Although it may be possible to correct for or avoid this behaviour, it is unlikely that the cost of a tagging programme would be warranted if its sole objective was to estimate the harvest. Additional objectives, such as the estimation of biomass may, however, make this approach more cost effective.

The only recreational rock lobster harvest estimates which are currently available are those derived from telephone diary surveys. None of these estimates are considered reliable enough to use in the current stock assessment. Although at least one significant source of bias has been identified in recent surveys, it is likely that further sources of bias probably remain, which may cumulatively lead to inflated harvest estimates, to an unknown and possibly indeterminable degree. Some of these biases could be avoided if estimates were generated solely from short-term recall telephone interviews. Another approach is to separately assess different components of the recreational fishery, to produce a combined harvest estimate. This fractured approach could lead to many sources of bias and the unintentional double counting of catches is also likely.

The final approach considered here is the aerial overflight approach, which is currently used to assess recreational harvests of commonly caught finfish species. This method is unsuited to estimating harvest where a large proportion of the harvest is taken by divers or fishers using pots. Related, but indirectly derived, harvest estimates are given here for the CRA 1 and CRA 2 fisheries, which should be treated with some caution, as they are based on a survey designed to estimate finfish harvests.

This review has highlighted problems associated with each approach and no single method is recommended. Because the incidence of lobster harvesting, and that of fishers targeting lobster, is low, it is unlikely that a dedicated survey would be warranted given the cost and likely accuracy of the results obtained. Future rock lobster harvest estimates may, therefore, be derived from multi-species harvest surveys, which may still be biased and of lower than desirable precision.

1. INTRODUCTION

Reliable estimates of recreational harvest are required for the assessment and management of New Zealand's rock lobster stocks, yet these are currently unavailable. Estimates of recreational lobster harvests have been derived from three national telephone-diary surveys in 1995–96, 1999–2000 and 2000–01. As with all telephone-diary estimates, however, considerable concern has been expressed about their reliability. The Recreational Technical Working Group recently recommended that these estimates should be used only with the following qualifications: *1) they may be very inaccurate; 2) the 1996 and earlier survey contain a methodological error; and 3) the 2000 and 2001 estimates are implausibly high for many important fisheries.* The Ministry has, therefore, decided that developing better estimates of recreational harvest should be a high priority in those stocks where recreational fishers take a large proportion of the total catch.

This report reviews methods which could potentially be used to estimate recreational harvests of rock lobster. A general overview of each method is followed by a discussion of the assumptions and pitfalls associated with each approach. Special consideration is given to the unique and diverse nature of recreational fishing methods which are used to target lobster, as all forms of effort should be considered if one or more approach is to be successful.

An attempt is also made to estimate the recreational harvest from CRA 1 and CRA 2, which is based on an aerial overflight survey of QMA 1 in 2004–05, a method more suited to estimating the harvest of finfish species. Lobster harvests are derived in a relative sense, using snapper harvest estimates and creel data collected at selected boat ramps.

Objective

1. To estimate the recreational harvest of rock lobsters (*Jasus edwardsii*) in selected fisheries.

Specific objectives

1. To estimate the recreational harvest of rock lobsters (*Jasus edwardsii*) in CRA 2 and the eastern part of CRA 1 by extension of the method used in REC2004/01.

2. To design an alternative method to the telephone and diary system for estimating the recreational catch of rock lobsters.

In this report we consider methods of fulfilling Objective 2 first, as it provides a context for Objective 1.

2. REVIEW OF POTENTIAL HARVEST ESTIMATION METHODS

2.1 Overview

A wide range of species are taken by recreational fishers, and, of these, annual harvests of rock lobster are among the hardest to estimate. Only a small proportion of fishers target rock lobster, using a variety of specialised methods to take their catch. It is, therefore, hard to both randomly sample catches and scale up these catches to determine the harvest by all fishers, as encounter rates are low and measures of effort differ according to the method used. A further complicating factor is that rock lobsters are taken by different methods throughout the country (Tables 1 & 2) necessitating a flexible and wide ranging survey design. It may be possible to estimate the recreational harvest for small discrete areas of coastline, but this is unlikely to be cost effective over the scale of one or more management areas.

Table 1: Proportion of rock lobster taken in each area by method. Data are from the 1999–2000 telephone diary survey held in the Ministry of Fisheries Rec_data database.

Method	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 7	CRA 8	CRA 9	Total
Line/trailer boat or dinghy	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.13	0.01
Line/launch of yacht	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Line/charter boat	0.03	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01
Shore/rod or handline	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diving/private boat	0.92	0.65	0.22	0.17	0.33	0.76	0.39	0.59	0.38
Diving/charter boat	0.03	0.08	0.01	0.00	0.01	0.00	0.47	0.00	0.03
Diving/shore	0.00	0.05	0.18	0.11	0.08	0.05	0.14	0.06	0.09
Dredging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Set/gill netting	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.01
Hand gathering	0.01	0.02	0.00	0.01	0.00	0.14	0.00	0.01	0.01
Potting	0.00	0.18	0.56	0.67	0.55	0.05	0.00	0.21	0.45
Spearing	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01

Table 2: Proportion of trips where rock lobster was taken or targeted in each area by method. Data are from the 1999–2000 telephone diary survey, held in the Ministry of Fisheries Rec_data database.

Method	CRA 1	CRA 2	CRA 3	CRA 4	CRA 5	CRA 7	CRA 8	CRA 9	Total
Line/trailer boat or dinghy	0.01	0.03	0.01	0.00	0.01	0.00	0.00	0.07	0.01
Line/launch of yacht	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Line/charter boat	0.02	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01
Shore/rod or handline	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Diving/private boat	0.89	0.51	0.27	0.15	0.30	0.77	0.28	0.47	0.37
Diving/charter boat	0.04	0.12	0.01	0.00	0.02	0.00	0.45	0.00	0.05
Diving/shore	0.01	0.06	0.16	0.20	0.10	0.08	0.14	0.13	0.12
Dredging	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Set/gill netting	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.01
Hand gathering	0.01	0.03	0.01	0.01	0.00	0.08	0.00	0.03	0.01
Potting	0.00	0.25	0.52	0.58	0.54	0.08	0.14	0.30	0.41
Spearing	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00

The outcome of any survey, and its potential biases, are partially determined by how observations are collected (the sample frame) and whether the data are recorded by the fisher or by an independent observer (observation independence) (Table3).

Table 3: Survey methods that can be used to estimate recreational harvests of rock lobster

Method type	Sample frame	Observation independence
Creel survey techniques	Trip	Direct
Tagging programmes	Fish	↓
Short term telephone diary surveys	Fisher	
Telephone diary/mail surveys	Fisher	
Multi-method recall surveys	Trip	Indirect

The sample frame is the level at which observations are collected (hopefully in a representatively random but scientific manner) such that they can be combined to describe the overall harvest from a fishery. At its simplest, harvests from a sample of trips can be used to estimate the average harvest from a trip, which is then multiplied by an estimate of the total number of trips taking place, the trip sample frame. Alternatively, harvests can be considered in terms of the probability of a fish being caught, with some associated estimate of how many fish there are in the vulnerable population, the fish sample frame. Finally harvests can be considered in terms of fishers, where a population of anglers is asked to record their catch over a given period, and these data are used estimate the average catch per fisher. This is the fisher sample frame, where the harvest from a fishery is determined by multiplying the estimated average catch per fisher by some estimate of the number of fishers accessing that resource. The nature of a fishery will determine the most applicable sample frame as, for example, it is likely that the researcher may have difficulty observing enough trips to describe the average trip harvest, or because fishers may be hard to identify and select in a truly random and representative manner.

Another consideration is how dependent the survey design is on fishers recording data on their own catches without independent verification, observation independence. Greater confidence can be attached to data when it is directly observed by an independent observer, who has been trained to record data in a given manner, according to a known survey design. A survey design has to be designed with the fishery in mind, however, as inherent biases in a poor design become essentially hardwired, and may go undetected. Cost is also an issue, as large scale surveys can require thousands of hours of staff time, and may incur other costs such as operating boats or aircraft. At the other extreme, harvest estimates can be collected without the researcher observing a single fish or fishing event. An example of this is a telephone diary survey, where the number of fishers is estimated from telephone interviews, and a selection of these fishers is asked to keep diaries, which they record themselves. Confidence in such estimates is based on the degree of trust that you have: in the accuracy of your estimate of the total population of fishers given the questions asked, in the degree to which voluntary participants are a random cross section of the fishing community, and, in how accurately fishers report all their catch and effort (and not that of others). This does not necessarily imply that there is any deliberate deception on the part of fishers, but rather that unintentional bias can occur at one or more stages, and because there are no observed data available on what actually took place, it is hard to detect and correct for such biases.

In the following sections the methods listed in Table 3 will be discussed in turn. As part of this review, the key fishing methods identified in Tables 1 and 2 will be taken into consideration, as some sources of harvest are harder to reliably quantify than others.

2.2 Creel survey techniques

Creel surveys are face-to-face interviews of fishers, usually occurring at the end of a trip. In the past they have taken place on the water or along the shoreline while fishers are still fishing, but most interviews in recent years have occurred at boat ramps, as fishing parties return to land. The sample frame is, therefore, at the level of the trip (catch per fisher per trip) and all data are directly observed and recorded by an independent researcher.

Rock lobsters are landed less frequently than many finfish species, as specialised methods, which are used only by a subset of fishers, are needed to target lobster. The spatial intensity of landings is also highly variable, as some areas are far more productive than others, and these areas are often remote. Access-based creel surveys are not, therefore, ideally suited to estimating the harvest from large-scale management areas. To some degree it is possible to optimise a survey to target ramps where lobster are commonly landed in a stratified manner, but landing rates are often still comparatively low, necessitating intense levels of sampling if recreational landings are to be quantified with any precision. Some measure of the overall number of trips taking place within an area is still required, unless all access points are considered in the survey design.

Not all harvests are landed at boat ramps, however, as launches and charter boats are often used to access some fisheries, and these vessels can return to shore some distance from the resource. Further, these fishers often return to land after several days fishing, when some of the catch may have been consumed. Shore-based diving also accounts for a proportion of the catch in some areas (see Tables 1 and 2) but these fishers can be elusive, as their effort is sporadic and dispersed.

Creel surveys are, therefore, best suited to estimating the rock lobster harvest from short areas of coastline, where trailer boats are almost solely used to access the fishery, or where all forms of effort are easily observed. Although it is conceivably possible to subsample the coastline, and derive scaled-up estimates for a larger area, the selection of random, yet representative, stretches of coastline is problematic.

Creel surveys are often an integral component of larger-scale harvest estimation techniques. Two examples of this are telephone diary surveys (where they are used to provide estimates of mean fish weight) and aerial overflight surveys (where they are used to determine the landed catch of a sample of fishers, which is then scaled up to account for the catch by all fishers, via an aerial count of all boats fishing at a fixed time). These techniques are discussed further on, and an adaptation of a 2004–05 aerial overflight survey is used to provide harvest estimates for CRA 1 and CRA 2, in Section 3.0.

2.3 Tagging programmes

Estimates of recreational harvest are sometimes derived from tagging programmes, usually as an incidental objective. Recreational harvest estimates are inferred from the number of tags returned by anglers relative to the number returned from a monitored source, such as a commercial fishery. Harvests are assessed at the relative level of the fate of a tagged fish, and individual harvests are verifiable insofar as a tag is required to demonstrate that a fish has been caught (but not necessarily landed).

Key assumptions are as follows:

- That reporting rates from both fishing sectors are the same. Reporting rates can be estimated by varying the value of rewards if rewards are sufficiently publicised (Nichols et al. 1991).
- That the availability of rewards or political considerations does not create an incentive to go fishing during the assessment period.
- That one type of fisher does not claim to be the other. Sampling of catches at their point of landing can partially overcome this issue.
- That tags are seeded into the population such that they are equally available to recreational and commercial fishers. Spatial and temporal stratification can partially address this issue.
- That fishers return tags only from fish they have landed, i.e., they don't cut tags off moulting lobsters or those carrying eggs.
- That tagged lobsters behave in a similar manner to the wider population.

Some of these assumptions are untestable, or hard to assess reliably. Regardless of these assumptions, the costs associated with a tagging programme are considerable, but additional information on growth,

movement, selectivity, and stock biomass may help justify the expense. Although these additional objectives may help justify a tagging programme, conflicting demands may reduce the accuracy of a harvest estimate. For example, commercial fishers returning tags as part of the 1990 SNA 8 tagging programme claimed to be recreational fishers, possibly to receive rewards, but to avoid adversely influencing biomass estimates (and hence the future Total Allowable Commercial Catch), which were based solely on commercial return rates. This behaviour would result in positively biased recreational harvest estimates.

2.4 Telephone diary or mail diary surveys

This approach combines an estimate of the number of fishers in a population (derived from a telephone survey) with catch data provided by diarists (who are also recruited from the telephone survey). Since the mid 1990s, telephone/diary surveys have included an additional boat ramp survey component, which has provided more accurate estimates of average weight of fish caught by diarists.

When a telephone survey is used to estimate the size of the fishing population, the following assumptions must be considered.

- That telephone interviewees respond in an open and honest manner. Pilot surveys for the 1999–2000 survey identified soft refusal behaviour, where individuals appeared to politely evade prolonged interviews by giving negative answers to introductory questions on fishing effort (Boyd & Reilly 2004). This bias was not considered in previous surveys.
- That everyone who can potentially go fishing has an equal chance of being contacted by phone. There is increasing use of ex-directory phone numbers and a switch from landlines to mobile phones is increasingly common, especially with younger generations.
- The number of fishers in a population is determined by asking respondents if they went fishing in the past year. Many fishers are tag-along fishers, whose initial response may be that they did not go fishing in the past year. The tendency of these fishers to go fishing is partially weather dependent, however, and prevailing conditions, during the Christmas break especially, could influence the fishing population size. This is less likely to be an issue for rock lobster fishers, who tend to be experienced specialised fishers.
- That respondents can accurately recall if they have been fishing during the period specified. Recall bias, or telescoping memory, is common (Wright et al. 2004), in which the frequency or magnitude of events tends to be increasingly exaggerated with time.

Respondents who claimed to be fishing in the previous year are asked if they would consider keeping a diary. The tendency to comply with this request may be age, sex or location specific, potentially leading to a biased sample of fishers. Non-random selection of diarists may be partially overcome by asking questions which stratify telephone respondents into categories, to which weightings can be applied to help correct for any bias, and to improve precision. These weightings are often based on data from the 5 yearly national population census conducted by Statistics New Zealand.

A telephone survey is not necessary when there is a list of fishers available already, which is the case for licenced fisheries. In such cases licencees could be selected at random to keep diaries, usually via a mail survey, which still has potential sources of bias. A compulsory rock lobster licence system was trialed in South Africa, but compliance levels were very low (Stephen Brouwer; Ministry of Fisheries, pers comm.). Biases associated with previous voluntary diary/logbook programmes are likely to be more pronounced if they become compulsory. Regardless, it is unlikely that a licence system will be adopted to manage New Zealand marine recreational fisheries in the foreseeable future.

Fishing diaries are also used to determine an average annual catch per fisher over a given period, usually in three month blocks. In doing this, the following are assumed.

- Fishers record only their catch, and no one else's.
- Diarists keep records for all trips where they catch fish. It is not actually necessary to record trips where there was no harvest, although they are usually asked to do this. Fishers may invent catches or trips if they feel embarrassed about their efforts.
- That diaries are filled out before a diarist's memory of a trip becomes diminished. This is another opportunity for recall bias. Some diarists may fill out their log books just before they send them in, at the end of a survey period.
- The number of diarists who catch a given species is enough to provide a good estimate of the average catch per fisher. This is especially a problem for rock lobster, as only a fraction of fishers are capable of catching rock lobster.
- The avidity of a fisher does not influence the probability that they will volunteer to be a diarist. Previous work has shown that, on average, diarists have substantially larger bag sizes than are observed during boat ramp interviews. One explanation for this is that diarists are better than average fishers, who are particularly interested in keeping a diary as it is an activity they frequently indulge in. This is often called diarist self selection

Evidence for the last two points is given in Table 4. The c.v.s on the CRA 1 harvests are high, as the numbers of diarists who landed lobster during the surveys were low given the variability in their harvests. The two diarists who landed the most lobster from CRA 1 accounted for 32–70% of the fish taken by all diarists in this area. The chance selection of these diarists, therefore, can have a marked influence on the final harvest estimates.

Large diarist sample sizes are desirable, therefore, to increase levels of precision and to reduce the influence of individual diarists with atypically high annual harvests. If fishers who caught lobster in the previous year are identified during the telephone survey, they can be treated as a separate stratum which is then oversampled to ensure that an adequate number of diarists are recruited. Catches from these diarists could then be down-weighted appropriately, to ensure that the deliberate oversampling of this subpopulation of fishers is corrected for. Boosting the number of rock lobster fisher diarists could be considered as a sub-objective of a larger national telephone diary survey. Alternatively, the number of diarists recruited could be universally increased, regardless of the fisheries they claim to have participated in, but this would not be cost effective solely for the purpose considered here. Bradford (2000) estimated that for CRA 2, about 450 diarists representative of the fishery would be required to get an estimate of annual harvest to a useful level of accuracy (see Table 4 for sample sizes achieved to date).

Regardless, finer scale examination of diarist data suggests that the most successful diarists are often those who fish with pots, yet relatively few fishers use this method, making it particularly hard to estimate the average fisher harvest.

Table 4: Estimates of recreational harvest of rock lobster (CRA) from CRA 1 and CRA 2 derived from telephone diary surveys. The contributions of the most avid, and second most avid, diarists are given to demonstrate their leverage on the final harvest estimate.

Stock	Year	Recreational harvest (t)	c.v.	No. of diarists catching CRA	% of catch	
					Top diarist	Top 2 diarists
CRA 1	1993–94	38–48	–	43	20	32
	1995–96	51	–	37	25	44
	1999–00	102	0.59	20	39	70
	2000–01	156	0.68	32	35	50
CRA 2	1993–94	95–123	–	87	25	31
	1995–96	138	–	109	6	10
	1999–00	236	0.26	71	13	22
	2000–01	241	0.27	65	13	19

The third aspect of this method is a creel survey, which is used to provide estimates of mean fish weight by species and area. Although diarist data on the number of fish caught are taken at face value, the average weight of these fish is independently derived from observations of catches landed at boat ramps. This is because a comparison of fish length data from diarists and from fishers returning to boat ramps, collected concurrently during the 1992–93 Central region telephone diary survey, suggested that diarists tended to overestimate the size of fish they retained (Ryan & Kilner 1994). All subsequent telephone diary surveys have relied, where possible, on creel survey data to provide mean weight estimates for each species in each area. In doing this it is assumed that the average size of fish caught by trailer boat borne fishers represents that of all fishers in the area. This is probably true for most, but not all, species, as some species are mostly taken from the shore, where the size of fish caught may differ from that caught in more open waters.

The assumptions discussed here, and associated potential biases, are not necessarily exhaustive. One of the main drawbacks to the telephone diary survey is that very little of the information used is actually observed independently, and must be taken at face value. It is, therefore, hard to ascertain the direction and magnitude of many of the sources of bias. The discovery of a soft refusal bias during preparation for the 1999–2000 survey helped correct for one issue, but also highlighted that one or more positive source of bias (possibly threefold) remained undetected, which has yet to be identified and estimated. It is unlikely that all sources of bias can be reliably and concurrently addressed by observation.

The feasibility of using telephone diary surveys to annually estimate the recreational harvest from CRA 1 to CRA 5 was considered by Bradford & George (2002), who concluded that *"...separate surveys to estimate rock lobster harvests would be difficult to carry out and expensive."*

This was followed by the suggestion that future harvest estimation should rely on larger surveys of the general recreational fishery for all species. The only rock lobster harvest estimates which are currently available for recreational fisheries are those derived from telephone diary surveys (Boyd & Reilly 2004, Boyd et al. 2004, Bradford 1997, 1998) (Table 3). The Rock Lobster Working Group has little confidence in these estimates (Sullivan et al. 2005).

2.5 Short term telephone surveys

Much of the uncertainty surrounding telephone diary surveys is related to recall bias, where the ability to accurately recall past events is diminished with time. Recall bias can, therefore, be largely overcome when respondents are questioned only about recent events, say in the last week or month.

Estimates of the number of rock lobster harvested by each respondent in the last week (or perhaps month) could be based solely on telephone interview data. Average fish weight data should still be derived from creel surveys. National census data could be used to generate a demographic weighting for each respondent.

A major problem with this approach is that the number of calls required to provide reasonably precise estimates of the average harvest in a week (or month) is likely to be high, given the low incidence of lobster harvesting, yet the number of surveys required to cover a year, or even the main fishing season, is also high. A licensing or registration system would enable a far more focused and cost effective sampling framework, if compliance with such a system was adequate. It is unlikely that this would be the case. In the first instance, the level of enforcement would probably be too low to compel fishers to comply, and secondly, a fisher's avidity may influence their tendency to comply. Levels of compliance and factors influencing this could be assessed in a scientific manner, but would require some cooperation by enforcement officers.

An advantage with this approach is that chance selection of a particularly avid rock lobster fisher is minimised as they influence the estimate only for the short period considered, and not a year. If questions are carefully phrased, catches could be attributed to the correct management area and the catch of others fishing with the respondent could be ignored.

2.6 Multi-method recall surveys

Lobster are mostly taken by four components of the recreational fishery, by potting, and by diving from charter boats, from private boats, and from the shore (see Tables 1 & 2). Collectively quantifying the harvests from these fishers using a single approach is problematic, as the nature of these fisheries differs considerably. The combined harvest could be estimated by using dedicated survey techniques to independently assess each fishery.

Some of the lobster caught by potters are landed at boat ramps, but not all. Probably the only means of potentially sampling all fishers using lobster pots with equal probability is via the telephone or some form of fisher/pot registration..

Charter boat harvests should, theoretically, be the easiest to quantify, as the Maritime Safety Authority could provide a list of charter boats. Charter boats are not currently required to keep logbooks, however, and recent experience suggests that many operators are reluctant to participate and remain in a voluntary survey. A mandatory charter boat logbook scheme has been proposed by the Ministry of Fisheries in a recent discussion paper, which should provide more reliable information if it comes into effect. Some form of data validation would still be desirable.

Divers who access the resource from private boats and from the shore could be approached via dive clubs or dive shops where they get their tanks filled. These two sets of divers are not mutually exclusive and may also use charter boats, so some care is required to avoid double counting of catches. Fishers could be asked about their last fishing event and associated catch when they pick up their tank, or as part of some club logbook. Although the number of dive shops and clubs is limited, so is the incentive for them to participate and maintain interest in a survey where they would be responsible for data collection and collation. It is highly likely that data collected from these agencies would be less than complete, to an unknown degree. Recall bias is also an issue here, as dive tanks are often filled some time after they were used, and the customer may be unable to reliably report what was caught and when. Further, the person taking a tank to be filled is often not the person who used it last.

Some lobster are taken by snorkel, from the shore and from launches. Only some of these skin divers, however, belong to clubs. These harvests are especially hard to quantify, as they are often taken in remote areas where there is no boat ramp.

2.7 Aerial overflight surveys

Aerial overflight surveys are currently the preferred method used to estimate the recreational harvest of commonly caught finfish species (Hartill et al. 2007a, 2007b). The method is most suited to estimating the harvest of species where the associated fishing effort is easily and unambiguously observed from an altitude of 500–1000 feet. Essentially, aerial counts of all boats fishing at a given time of day are used to scale up catch and effort observed throughout the day, at a subset of landing points.

The method is, therefore, most applicable to line fishing from a stationary boat, and is not a suitable method for directly estimating the rock lobster harvest. Potting effort cannot be assessed from the air, as they are visible only when the plane is directly overhead. It is also highly unlikely that an airborne observer would notice a diver who was not close to a stationary boat. Although it is possible to

identify divers from the air, usually by associated dive flags and characteristic surface bubbling on relatively calm waters, an unknown, yet substantial, proportion will remain unobserved.

Although it is not possible to directly observe all forms of fishing effort which target rock lobster from the air, it is still possible to assess the harvest relative to a more easily assessed fishery, such as that targeting snapper. An example of this is given in Section 3.0, where it is used to assess the harvest in CRA 1 and CRA 2. This oblique approach is still largely based on creel survey data, however, and the considerations discussed in Section 2.2 apply here also. Primarily, the intensity and extent of a creel survey would have to be of sufficient magnitude to obtain reliable and representative rock lobster landing rate estimates, which is beyond the scope of anything attempted over large spatial scales to date.

2.8 International harvest estimation approaches

A review of international recreational harvest estimates has been conducted by Melville-Smith et al. (2000) which describes international approaches, and provides harvest estimates for: Australia (most but not all states), America (Florida, Hawaii, and California), Africa (Atlantic Ocean, Indian Ocean, and Namibia), Bermuda, and New Zealand. The authors note that

"...this review shows that with few exceptions, reliable information on fishing activity or catches made by the recreational sector is only available in those countries in which rock lobster licences are sold."

An examination of the estimates given suggests that the main exception is New Zealand, where telephone diary estimates are provided, yet these are not considered reliable in New Zealand. This suggests that reliable estimates are available only from those countries that have a licence system. Although Melville-Smith et al. assume that licence based harvest estimates are reliable, this may not be the case, as no mention is made of whether these estimates were verified in any way. In the early 1980s, licence lists were used to provide a sample frame for recall diary surveys, which were used to assess the annual trout harvest in Lake Taupo. These estimates were considered to be potentially realistic, but the diary method was ultimately dropped in favour of an aerial overflight approach, which gave estimates which were far more consistent with other information on the fishery. The aerial overflight approach has now been used to assess harvests from this fishery for over 20 years and is considered to be far more reliable (Martin Cryer, Ministry of Fisheries, pers. comm.). Regardless, New Zealand does not have a marine recreational fishing licence system, and is unlikely to have one in the foreseeable future, if at all.

3. HARVEST ESTIMATES FOR CRA 1 AND CRA 2 FOR 2004–05

Although the aerial overflight approach (discussed in Section 2.7) is not a suitable means of directly estimating rock lobster harvests, an oblique but related approach is discussed here. Estimates of harvest are based on an aerial overflight survey of QMA 1, which provided snapper harvest estimates for the period 1 December 2004 to 30 November 2005 (Hartill et al. 2007a). Similar spatial stratifications were also used in this study, although parts of the inner Hauraki Gulf were dropped from the analysis, as there is usually no lobster harvest from this area (Figure 1).

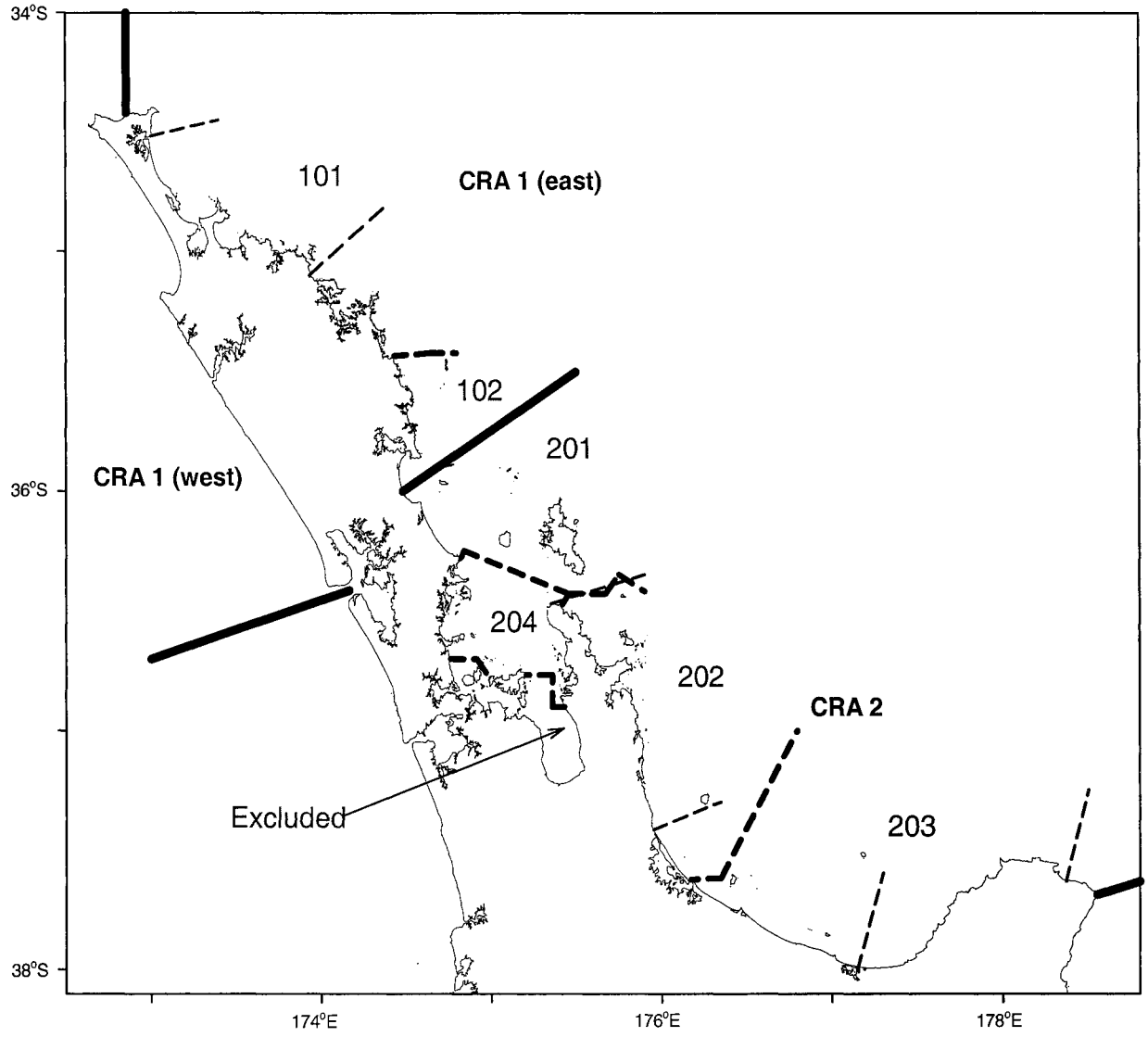

Figure 1: Spatial stratifications for which estimates of the harvest from CRA 1 and CRA 2 are derived. Solid bold lines denote the boundaries of CRA 1 (east and west) and CRA 2. Bold dashed lines and numeric codes denote analytical strata, which are partially based on those used for the original snapper harvest estimates. Finer dashed lines denote boundaries for Rock Lobster Statistical Areas.

3.1 Harvest estimate components

The two main estimate components required for this approach are an estimate of the ratio of lobster landed relative to that of snapper at surveyed boat ramps, and an estimate of the snapper harvest which is calculated following the methods described by Hartill et al. (2007b). The lobster harvest in a given stratum is, therefore, the product of a CRA:SNA ratio and a snapper harvest estimate. As part of the survey design, days were assigned to four temporal strata based on seasons and day types (Table 5).

Table 5: Aerial-access sample design for both the summer (1 December 2004 to 30 April 2005) and winter (1 May to 30 November 2005) seasons.

Season	Temporal strata	No. of days in strata	Days surveyed	Sampling intensity
Summer	Midweek days	97	10	0.10
	Weekends/holidays	51	19	0.37
	Furuno Fishing Competition	3	3	1.00
Winter	Midweek days	151	8	0.05
	Weekends/holidays	63	8	0.13

Lobster harvest estimates were calculated for two strata in CRA 1 (101 and 102) and for four strata in CRA 2 (201, 202, 203, and 204) (Figure 1). No attempt was made to estimate the harvest in the inner Hauraki Gulf ("Excluded") as lobster harvest here is almost non-existent (about 4 kg was landed by the 5260 fishing parties interviewed in 2004–05; Table 6) despite there being a considerable snapper harvest in this area.

Catch ratios were calculated for each stratum based on the observed weight of each species encountered by boat ramp interviewers during the 2004–05 survey (Table 6). Snapper length, and lobster tail width measurements were converted to catch weights using the length-weight relationships given in the 2005 Working Group Reports. Summertime catch weights were generally higher in all strata, mainly because the number of days sampled in this season was twice that during the winter months (Table 5). In some strata the number of parties interviewed, and lobster measured by ramp interviewers, was very low, potentially leading to inaccurate CRA:SNA catch ratios. In these cases, estimates of precision, which are based on 1000 bootstrapped catch ratios, are high.

Species catch ratios were then applied to snapper harvest estimates, which were calculated for the same spatial/seasonal strata (Table 7). The estimates of precision associated with the snapper harvest estimates were generated according to the bootstrapping methods described by Hartill et al. (2007b). Estimates of lobster harvest precision were calculated from the distribution of the product of the 1000 species catch ratio bootstraps and associated snapper harvest bootstrap estimates.

Table 6: Stratum and season specific ratios of the weight of snapper and rock lobster observed by boat ramp interviewers during the 2004–05 aerial overflight survey.

Stock	Area	Season	Parties Interviewed	Snapper catch (kg)	Crayfish catch (kg)	Species ratio	c.v.
CRA 1	101	Summer	491	1 231	96	7.8%	0.28
		Winter	155	462	41	8.9%	0.39
	102	Summer	2 298	7 151	349	4.9%	0.14
		Winter	611	2 027	137	6.8%	0.23
CRA 2	201	Summer	202	1 127	37	3.3%	0.38
		Winter	81	571	10	1.8%	0.63
	202	Summer	2 435	7 593	239	3.2%	0.14
		Winter	577	1 520	55	3.6%	0.28
	203	Summer	1 165	4 451	308	6.9%	0.15
		Winter	450	2 261	104	4.6%	0.27
	204	Summer	2 087	11 749	46	0.4%	0.28
		Winter	852	6 042	19	0.3%	0.41
	Excluded	Summer	4 283	22 418	2	0.0%	–
		Winter	977	4 052	2	0.0%	–

Table 7: Estimates of the boat-based harvest of rock lobster derived from aerial overflight estimates of snapper harvest and lobster to snapper landing ratios. Aerial estimates of the snapper harvest have been scaled to account for a small percentage of the harvest which is taken by longline. Seasonal harvests estimates are given for each spatial stratum of CRA 1 and CRA 2 which are combined to give harvest estimates for these management areas.

			Ratio of weight of CRA vs SNA		Aerial estimate of snapper harvest		Boat based CRA harvest	
Stock	Area	Season	ratio	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.
CRA 1	101	Summer	0.078	0.28	68.4	0.21	5.4	0.36
		Winter	0.089	0.39	55.7	0.39	4.9	0.57
	102	Summer	0.049	0.14	120.4	0.20	5.9	0.24
		Winter	0.068	0.23	91.2	0.22	6.2	0.31
	Total	Summer	–	–	188.8	0.15	11.2	0.21
		Winter	–	–	146.9	0.08	11.1	0.31
		Year	–	–	335.7	0.12	22.3	0.18
CRA 2	201	Summer	0.033	0.38	101.9	0.18	3.3	0.44
		Winter	0.018	0.63	78.5	0.32	1.4	0.79
	202	Summer	0.032	0.14	123.7	0.22	3.9	0.27
		Winter	0.036	0.28	78.8	0.19	2.8	0.32
	203	Summer	0.069	0.15	133.8	0.15	9.3	0.21
		Winter	0.046	0.27	118.7	0.19	5.5	0.33
	204	Summer	0.004	0.28	305.8	0.10	1.2	0.32
		Winter	0.003	0.41	312.5	0.18	1.0	0.44
	Total	Summer	–	–	665.2	0.20	17.7	0.15
		Winter	–	–	588.4	0.12	10.7	0.21
		Year	–	–	1253.6	0.07	28.4	0.12

3.2 Allowances for shore-based harvests

The estimates given above do not take the shore-based harvest of rock lobster into account, as they are solely derived from data collected on boat-based fishing. There are very few data available on the prevalence of shore-based harvesting, but the most recent source is diarist data from the 2000–01 telephone diary survey, which are summarised in Table 8.

Table 8: Summary statistics for diarists records of lobster catch and trips where lobster was caught during the 2000–01 telephone diary survey.

		Number of trips			Number of CRA landed		
Stock	Season	From boats	From the shore	Total	From boats	From the shore	Total
CRA 1	Summer	49	5	54	193	21	214
	Winter	43	1	44	187	1	188
	Total	92	6	98	380	22	402
CRA 2	Summer	137	6	143	512	23	535
	Winter	35	4	39	107	10	117
	Total	172	10	182	619	33	652

These data were used to determine how many lobster are landed by shore-based fishers relative to the numbers landed by boat-based fishers. The incidence of shore-based landings is so low, however, that a single event can have a marked leverage on the final result.

Diarist catch records were assigned to two groupings: boat-based catches (where the recorded method was recorded as diving from charter or private boats, line fishing from boats, potting and spearing) and shore-based catches (recorded as diving from shore and hand gathering). Seasonal scalars were calculated for CRA 1 and CRA 2 by simply dividing the total number of lobster landed by the number landed from boat-based fishers. These scalars were used to adjust the boat-based harvest estimates given in Table 6, to account for the shore-based harvest (Table 9). Trip landings were bootstrapped to provide estimates of precision, and these bootstraps were used in conjunction with those calculated previously to provide coefficients of variance for the final scaled rock lobster harvest estimates.

Table 9: Estimates of the recreational harvest from CRA 1 and CRA 2 that take shore-based harvests into account. Ratios of the seasonal shore-based harvest relative to the boat-based harvest were derived from diarist data collected as part of the 2000–01 telephone diary survey.

			Boat-based CRA harvest		Scalar to account for shore-based catch		Total CRA harvest	
Stock	Area	Season	Est (t)	c.v.	Scalar	c.v.	Est (t)	c.v.
CRA 1	101	Summer	5.4	0.36	–	–	–	–
		Winter	4.9	0.57	–	–	–	–
	102	Summer	5.9	0.24	–	–	–	–
		Winter	6.2	0.31	–	–	–	–
	Total	Summer	11.2	0.21	1.109	0.59	12.4	0.22
		Winter	11.1	0.31	1.005	1.12	11.2	0.31
		Year	22.3	0.18	–	–	23.6	0.18
CRA 2	201	Summer	3.3	0.44	–	–	–	–
		Winter	1.4	0.79	–	–	–	–
	202	Summer	3.9	0.27	–	–	–	–
		Winter	2.8	0.32	–	–	–	–
	203	Summer	9.3	0.21	–	–	–	–
		Winter	5.5	0.33	–	–	–	–
	204	Summer	1.2	0.32	–	–	–	–
		Winter	1.0	0.44	–	–	–	–
	Total	Summer	17.7	0.15	1.045	0.56	18.5	0.15
		Winter	10.7	0.21	1.093	0.64	11.7	0.22
		Year	28.4	0.12	–	–	30.2	0.12

3.3 Harvests for areas of CRA 1 and CRA 2 falling outside QMA 1

These estimates are based on an aerial overflight survey of QMA 1. Parts of CRA 1 and CRA 2 fall outside QMA 1, yet these too must be considered. For CRA 1 it has been assumed that the lobster harvest on the west coast of the upper North Island is minimal, and has been ignored. This assumption is based on diarist fishing location data (Figure 2) which suggest that almost all fishing effort takes place on the east coast, in QMA 1.

Almost all of CRA 2 is within QMA 1; a small section of coastline extends beyond Cape Runaway, however, as far as East Cape. This small section of coastline was also flown as part of this programme, and counts of fishing vessels in this area were also considered in the analysis. This stretch of coastline is very remote, however, and usually no recreational fishing vessels were observed in the area when it was over flown.

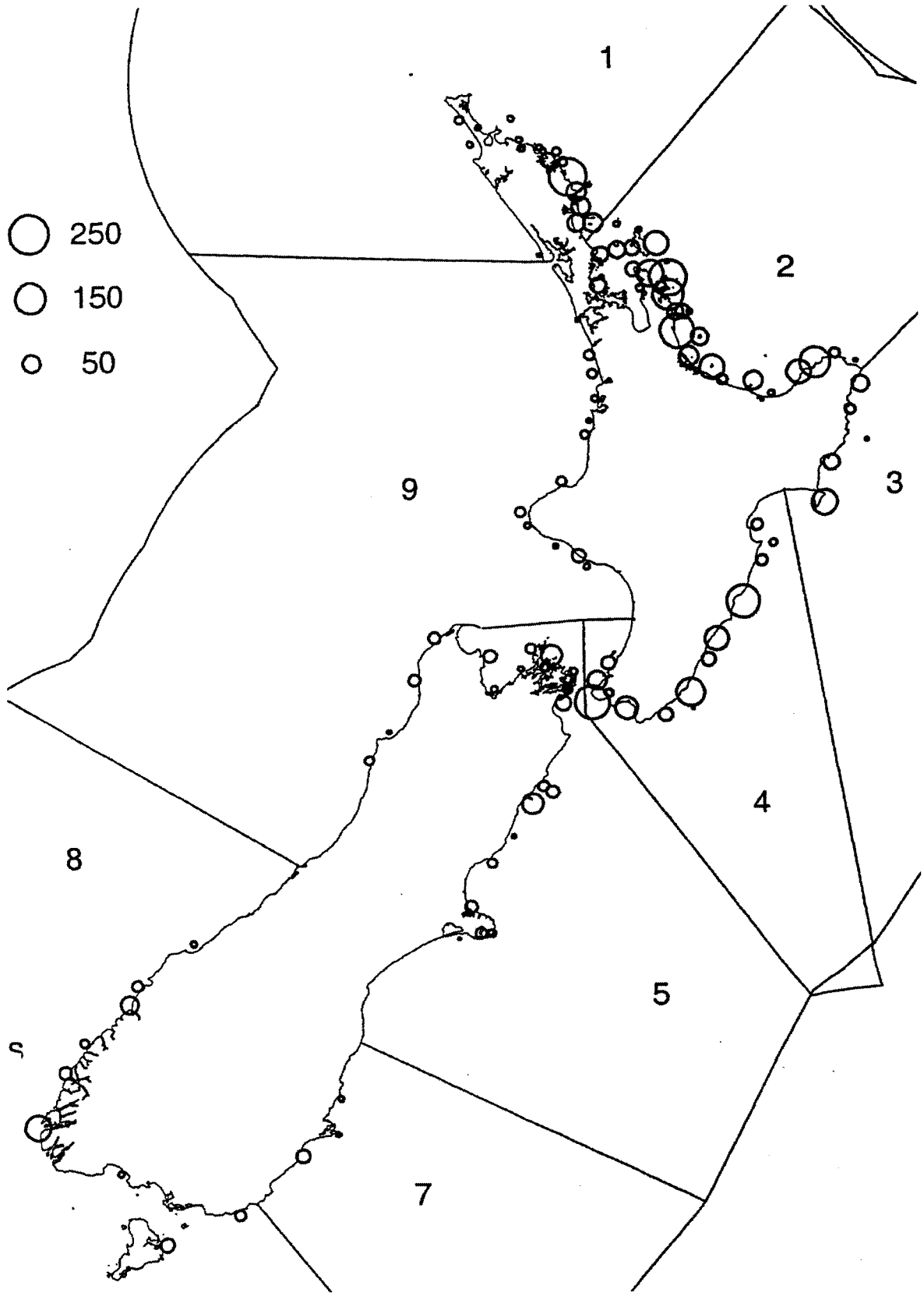

Figure 2: Number of rock lobster harvested by diarists during the 1996 telephone diary survey. Taken from figure 1 of Bradford & George (2002).

3.4 Accuracy of harvest estimates

These harvest estimates for CRA 1 and CRA 2 are largely derived from catch data collected at key boat ramps throughout QMA 1. Only the busiest ramps were surveyed in any given area, to ensure that the largest possible fraction of the recreational fleet was accessible for a limited level of interview effort. This is a cost effective and appropriate approach for assessing snapper harvests, as snapper is the most commonly caught recreational fish throughout QMA 1, and catch rates and size compositions are relatively homogeneous within each of the spatial strata originally considered.

Rock lobster abundance is, however, far more habitat dependent, and the more productive stretches of coastline are specifically targeted by both divers and fishers using pots. Most of the ramps used by rock lobster fishers were not surveyed, because they accounted for only a small proportion of the wider fleet's effort, or were often busy only on long weekends. It is likely, therefore, that the probability of snapper fisher being encountered was higher than that of a rock lobster fisher being encountered. If this was the case, then the snapper to rock lobster harvest ratios used in this analysis will be negatively biased, resulting in an underestimation of the harvest. Confidence in these catch ratios could have been increased with more extensive sampling of many more boat ramps, and a finer level of spatial stratification, but the cost and logistical requirements would have been far greater. The exclusion of the inner Hauraki Gulf from the analysis is in part a recognition of this issue.

A further problem with the approach taken is that it is assumed that landings at boat ramps provide a reasonable representation of the harvest by fishers from other types of vessel, including launches, charter boats, and yachts. This is unlikely to be the case. Fishers often take prolonged trips on larger vessels, and provide prolonged access to remote and productive arrears of the coastline. Further, catch rates on charter boats are probably higher than on private boats, as charter boat operators act as experienced fishing guides, ensuring that their clients have successful trips.

The harvest tonnages reported here are probably underestimates, therefore, and should be regarded with some caution.

4. CONCLUSIONS

- Only a small proportion of fishers target rock lobster, using a variety of specialised methods to take their catch, which is landed in a sporadic and often infrequent fashion.

- Although there are several approaches which could be used to assess recreational rock lobster harvests, all of them have aspects which could result in biased estimates.

- Because most fisheries have numerous landing points, a total census of any large-scale fishery by creel survey may not be practical, but boat ramp interviews can provide an integral component of a wider composite approach, such as a telephone diary or aerial overflight survey.

- Tagging programmes are not a cost-effective means of assessing recreational harvests, but this approach could be used if other non-conflicting objectives were considered, and emphasis was placed on obtaining accurate returns of information from fishers.

- Telephone diary surveys have been used in the past to estimate recreational rock lobster harvests, but are not considered reliable.

- Short-term telephone surveys would overcome many of the problems associated with conventional telephone diary surveys, but problems with low sample sizes could be addressed only if a list of rock lobster fishers was initially available.

- A range of concurrent focused surveys could be used to obtain harvest estimates for separate fishing method components of the fishery, but many fishers would fall within more than one sample frame, and some fishers would be missed altogether.

- Aerial overflight surveys are not suited to estimating rock lobster harvest, as it is not possible to assess most forms of effort from the air.

- An oblique form of aerial overflight estimate is given which uses snapper harvest estimates and snapper to rock lobster landing rates, but these estimates are not considered reliable because of the incidental and ad hoc fashion in which they are derived.

5. ACKNOWLEDGMENTS

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