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Aerial-access recreational harvest estimates for snapper and blue cod in FMA 7 in 2015–16

New Zealand Fisheries Assessment Report 2017/34

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This report provides estimates of the harvest of snapper and blue cod taken by the FMA 7 recreational fisheries in Golden Bay, Tasman Bay, and the Marlborough Sounds during 2015–16. The survey methods used to provide these harvest estimates were similar to those used in an aerial-access survey of the recreational fishery in FMA 7 in 2005–06, although some improvements were made to the survey design following a pilot survey conducted in 2014–15. There were two components to this complemented survey design method: a creel survey of recreational fishers returning to a subsample of high traffic boat ramps throughout the day; and an aerial survey count of fishing vessels made at the approximate time of peak fishing effort on the same day. The aerial count on each survey day was used to scale up a census estimate of the catch landed at the surveyed access points throughout the day, given the number of interviewed parties who claimed to have been fishing at the time of the aerial survey.

Interviewers were present at eight FMA 7 boat ramps on 54 days, randomly pre-selected according to a random stratified survey design. Flying was cancelled on three of these 54 days and partially curtailed on a further seven survey days, due to low cloud and or heavy rain. Aerial survey counts for unflown days were predicted given the relationship between aerial and creel survey based counts of boats on days when both surveys were fully implemented. This imputation of aerial counts for weather affected days was necessary because harvest estimates calculated solely from data collected on fully surveyed days (when weather was more conducive to flying and fishing) would have been positively biased. Aerial counts predicted from region specific regressions suggest that only 5.0 % of the effort that took place on these 54 days occurred on days when flights were cancelled, therefore any potential bias associated with these regression based "counts" is unlikely to have a major impact on the reliability of the harvest estimates.

The recreational harvest estimates generated from the aerial-access survey were 69.7 t for BCO 7 and 37.4 t for SNA 7. These estimates do not encompass all forms of recreational boat based fishing, however, as some methods such as longlining cannot be assessed from the air. When creel survey data on the relative catch by these methods was used to account for the additional harvest taken from boats, the harvest estimates increased to 71.0 t for BCO 7, and 76.3 t for SNA 7. A further adjustment to allow for shore based data, calculated using data from the 2011–12 National Panel Survey, has resulted in overall recreational harvest estimates of 74.8 t for BCO 7, and 83.1 t for SNA 7. These estimates are of a similar magnitude to those provided by the 2011–12 National Panel Survey.

Rock lobster and scallop harvest estimates have also been calculated, relative to blue cod and snapper landings, because fishing effort directed towards these shellfish species is not quantifiable from the air. These shellfish harvest estimates are not considered to be reliable, however, given the poor correspondence between the incidence of rock lobster and scallops landings relative to blue cod and snapper landings at some times of year in some areas. Alternative estimates for the two shellfish species, calculated relative to blue cod, and to snapper, were of a substantially different magnitude, and were estimated with poor precision.

Web cameras have also been installed overlooking two boat ramps, as part of this programme. Ramp traffic data provided by these camera systems will be combined with catch per trip data provided by a low intensity creel survey in the future, to provide a cost effective means of monitoring long term trends in recreational blue cod and snapper harvesting, so that we are able to interpolate between infrequent fishery-wide harvest estimation surveys in the future, such as that described here.

1. INTRODUCTION

The recreational fishery in FMA 7 is New Zealand's second largest recreational blue cod fishery (Wynne-Jones et al. 2014) and most of this harvest is taken from the Marlborough Sounds (Davey et al. 2008). Golden Bay, Tasman Bay and the Marlborough Sounds also support valued recreational fisheries for snapper, scallops, rock lobster, as well as a variety of other less commonly caught species. The current status of these fisheries varies considerably.

There have been numerous changes to recreational fishing regulations for blue cod since the mid 1980s, which have mostly taken the form of changes to minimum legal size and daily bag limits. Most of these changes have been for the Marlborough Sounds fishery where the minimum legal size went from: 30 cm in 1986; to 33 cm in 1993; to 28 cm in 2001; and to 30 cm in 2003. A slot limit was introduced in 2011, allowing fish between 30 cm and 35 cm to be harvested, but this was changed to a 33 cm minimum legal size on 20 December 2015 (during the year surveyed as part of this programme). The daily bag limit in the Marlborough Sounds was also progressively decreased from 12 fish in 1986 to 2 fish in 2011. The daily bag limit for BCO 7 outside of the Marlborough Sounds has been 20 fish since 1993, which is when the current 33 cm minimum legal size limit was first gazetted.

Potting surveys have been used to monitor changes in blue cod abundance in the Marlborough Sounds since 1995 and, by 2001, these surveys suggested that cod abundance had halved since 1995. Continuing concerns about blue cod abundance led to a moratorium on blue cod harvesting in the Marlborough Sounds, from 1 October 2008. When the moratorium was lifted in April 2011, anecdotal reports suggested that there had been a noticeable increase in blue cod abundance, but new management measures were introduced to constrain fishing pressure, including a seasonal closure to cod harvesting in the Marlborough Sounds between 1 September and 18 December and the introduction of the 30 cm to 35 cm slot limit. A potting survey conducted in 2013 suggests that abundance had declined, despite the restrictions on blue cod harvesting introduced in 2011 (Ministry for Primary Industries 2016).

In contrast, anecdotal recreational fishing reports and commercial statutory fishing returns all suggest that there has been a substantial increase in the abundance of snapper in Golden Bay and Tasman Bay in recent years. This sudden increase in abundance is mostly due to the recruitment of an exceptionally strong 2008 year class, which has been followed by a stronger than average 2011 year class (Parker et al. 2015).

The abundance of scallops in SCA 7 has been very low in recent years, and the Minister for Primary Industries prohibited recreational and commercial scallop harvesting in the Marlborough Sounds and eastern Tasman Bay (including Croisilles Harbour) from 15 July 2016, until further notice. The status of the rock lobster fishery in this area is more promising, however, as the 2015 CRA 5 stock assessment (MPI 2016) suggests that there are no sustainability concerns for this stock (Farewell Spit to the Waitaki River). One of the main sources of uncertainty associated with the CRA 5 stock assessment, however, was the lack of information on levels of non-commercial harvesting.

There is therefore an ongoing and pressing need to quantify the recreational harvest of several popular species that are taken from Golden Bay, Tasman Bay and the Marlborough Sounds. While recreational harvest estimates are available for this area, from a regional telephone survey conducted in 1992–93, and three national telephone diary surveys in 1996, 1999–00, and 2000–01, none of these estimates is considered reliable. There were two substantial onsite surveys of recreational fisheries in FMA 7. The first of these was a survey of the recreational scallop and dredge oyster fishery in Golden Bay and Tasman Bay (Cole et al. 2006) and the second was a characterisation and aerial-access survey of all of FMA 7 (except for that occurring on the exposed and relatively unfished northern west coast of the South Island) which was conducted in 2005–06 (Davey et al. 2008). The most recent recreational harvests that are available are those provided by the 2011–12 National Panel Survey (Wynne-Jones et al. 2014), which are considered to be broadly reliable.

This report describes an aerial-access survey of Tasman Bay, Golden Bay, and the Marlborough Sounds, which was conducted to provide estimates of the recreational harvest of blue cod, snapper, rock lobster and scallops taken from these areas between 1 September 2015 and 31 August 2016. Recreational fishing in these areas accounted for 98% of the National Panel Survey estimate for SNA 7 in 2011–12 and 91 % of the BCO 7 harvest estimate (Jeremy Wynne-Jones, National Research Bureau, unpublished data). The methods used in this survey were based on those used in 2005–06, although some changes were made to the survey design following a pilot survey that was conducted during the summer of 2014–15 (Hartill et al. 2015a).

The objectives of this study were:

1. To estimate the recreational harvest of blue cod in BCO 7, snapper in SNA 7, and the relative harvest of scallops in SCA 7 and rock lobster within the survey area in FMA 7.

2. To establish two web camera sites in FMA 7, at Waikawa and at Nelson.

2. METHODS

2.1 Overview

The maximum count aerial-access survey used to estimate recreational harvests of blue cod, snapper and other finfish commonly landed in Golden Bay, Tasman Bay and the Marlborough Sounds in 2015–16 was closely based on methods developed during similar surveys conducted by NIWA since 2003–04 (Hartill et al. 2007a, 2007b, Davey et al. 2008, Hartill et al. 2011, 2013). This aerial-access approach follows a complemented survey design (Pollock et al. 1994) that combines data from two concurrent surveys to estimate the harvest taken on a randomly preselected survey day: an aerial survey of the boat based fishery; and a census of fishers returning to a subsample of access points throughout the survey day.

The aerial survey provides a count of the number of vessels fishing at a point in time, preferably at the time of maximum fishing effort. This aerial count is used to scale up a creel survey census estimate of the catch landed at a subsample of access points throughout the day, given the number of interviewed parties who claimed to have been fishing at the time of the aerial survey. Both the aerial survey and the creel survey were scheduled to occur on the same randomly preselected days, so that the data collected could be combined to estimate the harvest taken on each survey day. The resulting daily harvest estimates, scheduled according to a random stratified design, are averaged within each temporal stratum and multiplied by the number of days occurring in each stratum, to provide day-type, seasonal, and consequently, annual harvest estimates.

The survey year was divided up into three seasonal strata: a “closed summer” season (1 September to 19 December 2015) that coincided with the seasonal ban on blue cod harvesting in the Marlborough Sounds; an “open summer” season (20 December 2015 to 30 April 2016) which started when blue cod harvesting was once again permitted in the Marlborough Sounds, and a “winter” season (1 May to 31 August 2016) (Table 1).

Table 1: Allocation of survey days to seasonal/day-type strata.

Season	Day-type	Days available	Days surveyed	Sampling intensity
Closed summer	Weekend/public holiday	32	10	31%
	Midweek	78	8	10%
Open summer	Weekend/public holiday	64	12	19%
	Midweek	69	8	12%
Winter	Weekend/public holiday	36	8	22%
	Midweek	87	8	9%
		366	54	

Each seasonal stratum was further divided into two day-type strata: midweek days; and those falling on weekends or during public holidays. All days falling between 25 December 2015 and Wellington Anniversary Day (25 January 2016) were treated as public holidays, because many Wellingtonians take an extended Christmas break over this period, and may cross the Cook Strait to fish in the surveyed area. A higher level of survey effort was allocated to the two summer weekend strata, as potentially higher and more variable levels of recreational fishing effort were expected on these days.

The same spatial strata definitions were used for both the aerial and creel surveys, which were the same as those used in the 2005–06 aerial access survey of this fishery (Davey et al. 2008; Figure 1).

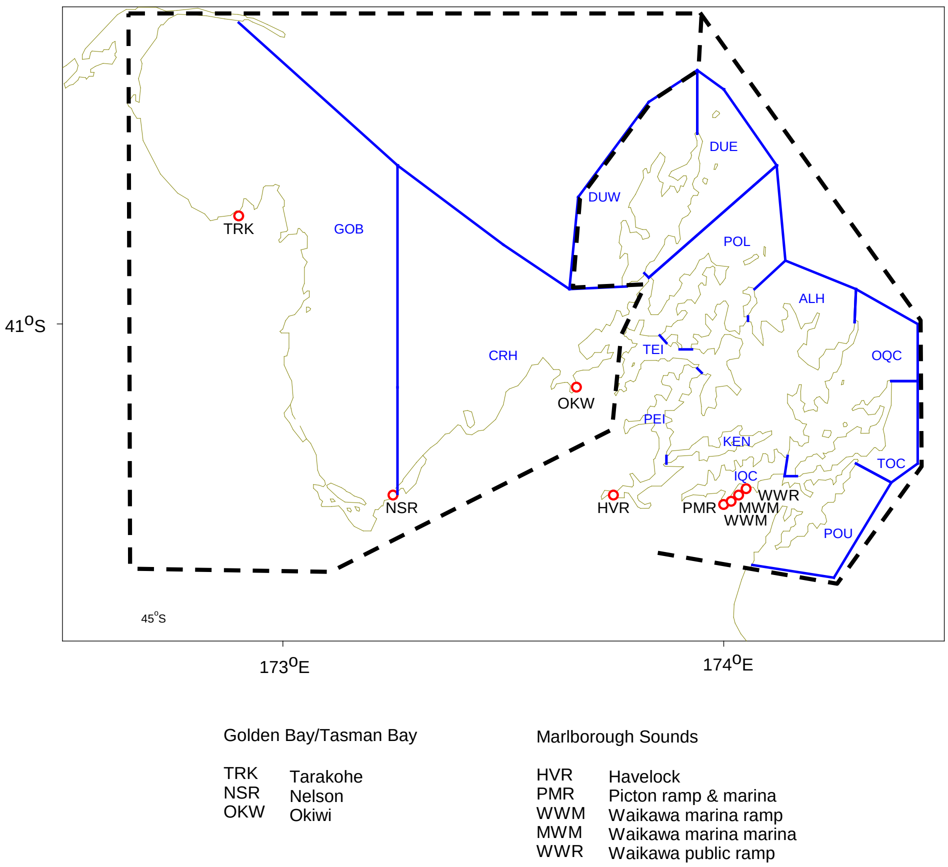

Figure 1: Location of boat ramps and definitions of spatial strata used in both the aerial and boat ramp surveys. Data from smaller fishing zones delineated by solid blue lines were combined into three analytical strata, delineated by dashed black lines: Golden Bay/Tasman Bay, Inner Marlborough Sounds, and Outer Marlborough Sounds.

2.2 Creel survey methods

Recreational fishing parties were approached when they returned to one of the eight surveyed ramps/marinas (see Figure 1), which were selected following a pilot survey conducted during the summer of 2014–15. These survey sites were selected because they were the access points with the highest rate of traffic in Golden Bay, Tasman Bay, and the Marlborough Sounds (Hartill et al. 2015a), thereby maximising the number of boating parties interviewed per hour surveyed. Only two ramps were surveyed in the Marlborough Sounds during the 2005–06 aerial survey (at Havelock and at the public ramp at Waikawa), but interviews at these two sites did not provide enough data to adequately characterise boat based effort and landings from these waters at that time. Creel surveys were therefore conducted at another three access points in the Marlborough Sounds during this study; at the marina and the marina ramp at Waikawa; and at the smaller combined ramp and marina facility at Picton.

The format of all interviews followed that used in all other creel surveys undertaken by NIWA to date. Standardised interview methods and survey forms have been developed and tested by NIWA over the past 20 years, and the interview methods used in this study drew on these systems and experience. Data were recorded on: the access point location; the survey date; weather conditions at the beginning of each interview session; the number of fishers in each party; vessel type; the time at which the vessel returned to the access point; the fishing methods used by each fisher; species targeted; areas fished; fishing start and finishing times; fisher experience; fisher age and sex; the number of each species caught; the method by which each was caught; whether each fish was retained or released; and the size of those landed fish made available for measurement.

Interviewers were continuously present at surveyed access points between the hours of 0800 and dusk, on the same days as those selected for the aerial survey. The interview data collected throughout the day at each ramp can therefore be used to provide effective census estimates of the number of boats using each ramp, and the associated catch of each species landed at the surveyed ramp on each survey day. The catch and effort of five types of boating parties must be considered when constructing daily census estimates for each surveyed ramp:

- fishing parties who participated in an interview;
- boating parties who claimed not to have gone fishing on the day.
- boating parties who refused to be interviewed, but had evidently gone fishing that day;
- boating parties who may or may not have gone fishing on that day but who were not intercepted because the interviewer was busy interviewing another boating party;
- boating parties who refused to be interviewed, who may or may not have gone fishing that day.

Interviewers were instructed to record the time at which each boat returned to the access point and to classify the interview outcome for each boat as one of the above. This chronological listing of interview outcomes was used when calculating semi-imputed census catch and effort estimates, as described below.

In the simplest case, the catch and effort data provided by interviewed fishing parties can be summed to provide the basis for a census estimate of daily catch and effort.

Many other intercepted parties claimed to have used their boats for purposes other than fishing, and in this case their catch and effort was assumed to be zero, when there was no evidence to the contrary.

While the vast majority of fishers encountered were willing to participate in a survey, a very small percentage (1–2%) of boating parties refused to be interviewed or pretended they had not gone fishing, despite good evidence to suggest that they had fished. The interviewer classified these boating parties as “fishing but refused” and a copy of the catch and effort data provided by the most recently interviewed fishing party was used to provide an imputed estimate of the catch and effort undertaken by each “refusing” party, to provide an estimate of their catch on that day.

The remaining boats are those that were not directly approached because the interviewer was busy interviewing another boating party, and, those who refused to be interviewed whose preceding activity was uncertain. In both these cases a copy of the catch and activity of the most recently interviewed boat was used to provide and imputed estimate for each of these uninterviewed boats. If the most recently interviewed boat had not gone fishing, for example, then we assumed that the uninterviewed boat had also not gone fishing. If, however, the most recently interviewed boat had gone fishing, then a copy of their catch and effort was assigned to the uninterviewed vessel.

The resulting chronological listing of interviewed and uninterviewed (but imputed) boating parties was generated when the data collected throughout the day was analysed, to provide both an estimate of the number of boats and weight of fish returning to the surveyed access point throughout the day, and to estimate the number of boats using that ramp that may have been fishing at any time of day, including at the time that each spatial stratum was surveyed from the air.

Interview data collected during the creel survey can also be used for other purposes:

- to provide information on the proportion of interviewed parties that used their boats for fishing and on the average weight of the catch landed these fishing parties. These data can be combined with web camera based traffic data, collected at the Nelson and Waikawa marine ramps, to monitor long term trends in the recreational harvest of key species in nearby waters. This interview/web camera based monitoring approach has, and is, used elsewhere to monitor trends in effort and harvesting at 11 boat ramps throughout the North Island (Hartill et al. 2015b);
- to provide species-specific mean weight estimates for a forthcoming National Panel Survey in 2017–18, so that catches reported by panellists can be converted into catch weight estimates;
- to provide a basis for any future analysis of recreational bag size and minimum legal fish size that fisheries managers may require when considering changes to current management settings.

2.3 Aerial survey methods

Counts of recreational fishing vessels were made by an observer from a Cessna 185 fixed wing aircraft, flying at an altitude of between 500 (the minimum altitude permissible under civil aviation regulations) and 1000 feet. Flights lasted up to 6 hours, starting from Takaka at 09:00, with refuelling stops at Nelson Airport once Golden Bay and the western Tasman Bay had been surveyed, and at Blenheim after the eastern Tasman Bay and outer Marlborough Sounds had been flown. A typical flight route is shown in Figure 2.

A pool of three observers was trained to ensure that at least one observer was available on any given randomly-selected day. Counts of vessels fishing within each of the analytical strata shown in Figure 1 were treated as instantaneous counts, as an aircraft can transverse these areas far quicker than any recreational vessel. The pilots acted as a secondary observer, counting all boats on his side of the plane and indicating their location to the observer. This necessitated clear communication between the two parties, as to who was counting which boats in which areas, with overall responsibility resting with the primary observer. Navigation was left to the pilot, although intervention by the observer was sometimes necessary when they felt that the area was not being covered to their satisfaction, or when the pilot was not affording the observer the best possible view of most of the boats.

Aerial observers recorded the location of each fishing boat on tablet PC software developed specifically for this purpose, which was first used for an aerial-access survey of the recreational fishery in QMA 1 in 2011–12. The tablet PC was linked to a GPS receiver which continuously indicated the location of the plane on an ArcPad GIS application, against a marine chart background. The observer used a stylus to mark the approximate position of each boat relative to the position of the plane and local landmarks, using different symbols to denote different boat types: trailer boat, launch, yacht, kayak, or charter boat (when it was obvious that a boat is a charter boat). The flight path of the plane was also digitised. The shape files generated by the ArcPad app were subsequently imported into an ArcMap database that could be used to combine or subset data collected during all survey flights.

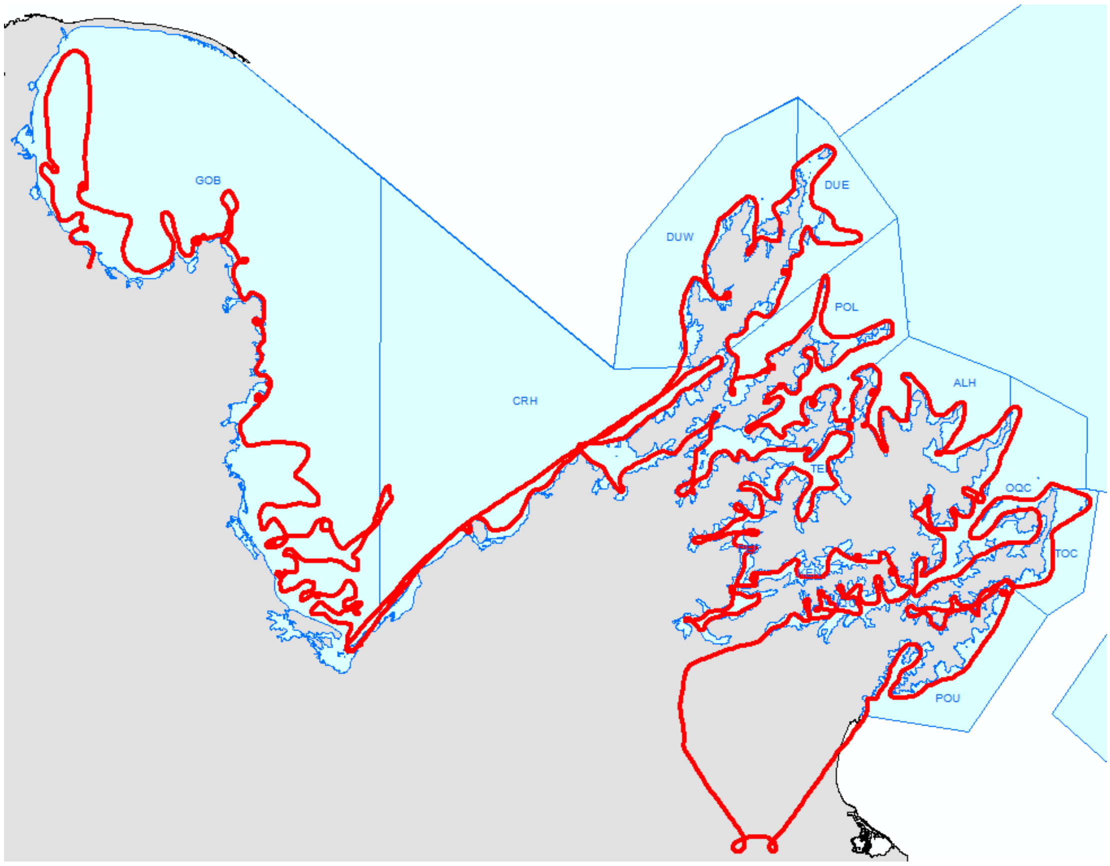

Figure 2: Typical flight route followed during an aerial survey of the recreational fishery in Golden Bay, Tasman Bay and the Marlborough Sounds.

The aerial survey provided counts of all types of fishing vessels, including larger vessels that would not normally return to boat ramps, such as those surveyed in the concurrent access point survey. Although approximately 80% of vessels observed from the air were classified as trailer boats, most of the remainder (launches, and to a lesser extent yachts and charter boats) would have returned to marinas and moorings which are difficult to survey. Counts of vessels other than trailer boats were therefore rescaled on the basis of relative occupancy rates, so that all aerial counts could be expressed in terms of trailer boat counts. The boat type occupancy data used to rescale the launch, yacht, charter boat, and other vessel counts was collected during a series of on-the-water surveys undertaken in the Marlborough Sounds in 2014–15, as part of a pilot survey for this programme (Hartill et al. 2015a). The derived occupancy rate scalars were: trailer boats, 3.06 fishers; launches, 3.17 fishers; yachts, 1.75 fishers; charter boats, 6.0 fishers; kayaks and jet skis, 1 fisher. All launch boat counts, for example, were therefore multiplied by a factor of 3.17/3.06, to account for the higher occupancy of this vessel type relative to that encountered at boat ramps, i.e., trailer boats. The use of scalars assumes that trailer boat fisher catch rates and fishing durations are broadly similar to those of fishing from other types vessel observed in the same area.

Flights were sometimes cancelled because of low cloud, but estimates of the number of boats fishing at a typical flight time are required for each survey day. Rescheduling to an alternative unscheduled day would lead to positively biased harvest estimates, as this would tend to favour days with weather more conducive to flying and fishing. Weather conditions associated with low cloud usually supress levels of fishing effort, so a harvest estimate for an unflown day would be negatively biased if the flight count was assumed to be zero, but positively biased if the flight count was based on the average count from the other days which were flown (when weather conditions were on average potentially far more conducive for fishing).

To avoid these potential biases, estimates of what aerial survey counts would have been had flying been possible are therefore required for unflown days, and these were predicted from the relationship between aerial and creel survey based counts of boats on days when data were available from both of these companion surveys. Separate predictive relationships were generated for each analytical stratum, which were used to estimate the number of boats that would have been seen from the air given the level of effort observed at surveyed access points on the same day (see Figure 5).

The uncertainty associated with these regression based aerial count estimates was estimated by bootstrapping and then regressing the paired aerial and ramp count data. Both the intercepts and the slopes of these regressions were refitted for each bootstrap, with the constraint that the intercept was zero positive (negative levels of predicted fishing effort cannot occur).

2.4 Calculating harvest estimates

A detailed description of the analytical methods used to calculate aerial-access harvest estimates and associated estimates of precision is given in Appendix 1 of Hartill et al. 2013, but a brief description is given here.

Aerial count and fisher interview data were combined for each survey day to estimate the harvest of a given species on that day. The observed and imputed (as described in Section 2.2) interview data provides a census of all boats returning to a subsample of access points throughout the day, both in terms of fishing effort and landed catch. This cumulative time series of observed and imputed interview data can be used to estimate the number of parties who claimed to be fishing at the time that they would have been counted from the air, and the total catch landed at each ramp on each day. The instantaneous aerial count of fishing boats made on the same day can then be used to scale up the combined catch of fishers crossing a subsample of all access points, given the number of fishing parties (boats) who claimed to have fished at the time of the aerial count on that day.

Daily harvest estimates, collected according to a random stratified design, were averaged within each temporal stratum and multiplied by the inverse of the sampling intensity for that stratum to provide harvest estimates for entire temporal strata. Stratum specific estimates of uncertainty were generated by a nonparametric bootstrapping procedure implemented in R. Harvest estimates were calculated for three analytical strata, which were amalgamations of the 13 fine scale survey strata used in both the aerial and access point surveys (see Figure 1).

The aerial-access method does not account for the harvest taken by some forms of non-rod and line boat based fishing, which are not readily enumerated from the air (such as longlining, set netting, diving and trolling which may also take place during a fishing trip) and the additional tonnage taken by these methods was estimated relative to the aerial-access harvest estimate for each fishery. When fishers were interviewed they were asked which fish were taken by which method, and region specific boat ramp data were used to estimate the proportion of the catch that was taken by these unassessed methods in each season. Almost all of the blue cod taken by recreational fishers were taken by stationary boat based methods, and there was very little difference in the average weight of cod taken by any given fishing method. The average weight of snapper taken by methods such as long lining and set netting, was substantially higher than the average weight of snapper taken by rod and line fishing, which could be quantified from the air. The estimates of the proportion of the snapper catch taken by non-rod and line methods was therefore calculated in terms of fish weight, rather than numbers of fish.

These proportional estimates of the boat based catch taken by rod and line and non-rod and line method groups were then used to scale up the aerial-access harvest estimates for each combination of species, area and season as follows,

$$\hat{H}_b = \frac{1}{1 - r_{\bar{a}}} \hat{H}_a$$

where $\widehat{H_b}$ is the harvest taken by all boat based fishers, $\widehat{H_a}$ is the harvest estimated by the aerial-access survey, and $r_{\bar{a}}$ is the proportion of the catch harvested by non-rod and line boat based fishers which cannot be enumerated from the air.

These estimates were then scaled up to account for the additional harvest taken by shore based fishers. The data used to estimate the proportion of the recreational harvest of blue cod and snapper taken by shore based fishers in FMA 7 was that provided by panellists during the 2011–12 National Panel Survey (Wynne-Jones et al.). These proportional estimates were then used to scale up boat based harvest estimates for each combination of species, area and season as follows,

$$\hat{H} = \frac{1}{1 - r_{\bar{b}}} \hat{H}_b$$

where $\hat{H}$ is the harvest taken by all fishers, and $r_{\bar{b}}$ is the proportion of the catch harvested from the shore.

Variances associated with both the indirectly assessed boat based, and shore based fishers were estimated by bootstrapping the underlying data 1000 times, and then applying these bootstrap scalars sequentially to the 1000 bootstrap estimates generated from the aerial-access survey.

2.5 Calculating relative harvest estimates for rock lobster and scallops

The aerial-access survey method cannot be used to estimate recreational harvests of shellfish species such as rock lobster and scallops, because much of the effort directed towards these species cannot be quantified from the air. Rock lobster are primarily taken by snorkelers, scuba divers and recreational rock lobster pots, but none of these harvesting methods is readily and reliably apparent from the air. Scallops are taken by both diving and dredging, but the dive based component of the harvest cannot be assessed from the air.

Information is available however, on the weight of these shellfish species landed by fishers returning to ramps during creel survey interviews conducted as part of the aerial-access survey. The ratio of the landed weight of a shellfish species relative to the landed weight of a finfish species can be used to estimate the shellfish harvest, when this ratio is applied to a finfish fish harvest estimate that has been reliably derived from an aerial-access survey. The resulting estimate of the boat based harvest of a given shellfish species is then further scaled up to also account for shore based fishing, based on data provided by panellists during the 2011–12 National Panel Survey (Wynne-Jones et al. 2014), in a similar manner to that described in the previous section (when scaling estimates of the boat based finfish harvest to account for shore based finfish harvesting). This relative harvest estimation method has been used to estimate recreational harvests from CRA 1 and CRA 2 in 2011–12, given concurrent aerial-access survey estimates of the snapper harvest (Hartill 2008).

A second method of estimating recreational rock lobster and scallop harvest estimates was proposed when relative harvest estimates for these species were presented to the Marine Amateur Fisheries Working Group in December 2016. With this alternative method the combined weight of each species landed at all surveyed ramps within an area is scaled up by the ratio of the number of fishing boats observed at the time of the over flight relative to the number of fishing parties who claimed to be fishing at the time of the overflight (rho – the inverse of which is an estimate of the proportion of boats surveyed from the air that returned to surveyed ramps). Harvest estimates for all survey days falling within each temporal stratum are then averaged and scaled up by the number of days falling within each temporal stratum. Variance estimates were calculated by bootstrapping survey day harvest estimates within each temporal stratum, which were then averaged and scaled up in an identical manner to that done for actual estimates. This method is essentially that already used to calculate harvest estimates for blue cod and snapper, but it relies on the untestable assumption that estimates of rho calculated for types of fishing effort such as diving, rock lobster potting and scallop dredging will be the same as those already calculated for rod and line fishing form stationary boats. Rock lobster and scallop harvest estimates have also been calculated by this method, for comparative purposes.

2.6 Web camera installations

Daily boat ramp traffic count data provided by web cameras have been used to monitor long term trends in recreational effort in QMAs 1, 2, 8 and 9 (Hartill et al. 2015b) and to assess the representativeness of aerial access-survey days in QMA 1 in 2011–12 (Hartill et al. 2013).

Two web cameras have been installed as part of this programme, overlooking boat ramps in the Nelson and Waikawa marinas, which will be used to monitor recreational effort in Golden Bay/Tasman Bay and the Marlborough Sounds respectively. Imagery of the Nelson marina boat ramp was available from the first day of the survey year (1 September 2015) because NIWA was able to patch into an existing video camera operated by the Nelson Port Authority, but the web camera overlooking the Waikawa marina boat ramp was not operational until mid-December, in time for the start of the “open” summer season on 20 December 2015.

Images collected by these two cameras have been interpreted from a stratified random sample of 60 days from the 2015–16 fishing year, to provide traffic counts for the first year of an ongoing fishing effort index at each of these ramps, following the methods used for ramps in QMAs 1, 2, 8 and 9 (Hartill et al. 2015b). The analysis of these traffic counts will be reported as part of another nationwide web camera monitoring programme (MAF2014/04). The selection of the 54 aerial-access survey days was intentionally aligned with the 60 preselected web camera image interpretation days, to verify traffic count data recorded during boat ramp interviews.

The imagery collected by the cameras overlooking the boat ramps at Nelson and Waikawa could also be used to assess how representative the days surveyed during the 2015–16 aerial-access survey were in terms of boat ramp traffic. In order to do this it would be necessary to interpret images collected during more days than the 60 days on which web camera imagery have already been interpreted to provide traffic index data.

3. RESULTS

3.1 Creel survey

The creel survey sampling design was almost completely implemented, with interviewers present at all eight of the selected access points during throughout the day on all 54 randomly preselected survey days, with two exceptions. There was no interviewer present at the Nelson Marina ramp during the morning of 20 March 2016, and the public ramp at Waikawa was closed to the public for maintenance on 29 September 2015. The number of boating parties returning to other neighbouring surveyed boat ramps on these two days should have been sufficient to describe daily catch and effort profiles for harvest estimation purposes on these days.

Almost 90% of boating parties returning to the surveyed ramps were interviewed, with only 972 out of 9002 returning boats passing through a surveyed ramp without being approached by an interviewer, because they were busy interviewing another party (Table 2). Most boating parties returning from Golden Bay and Tasman Bay (at Tarakohe, Nelson Marina, and Okiwi) had been fishing, but most boats returning from the Marlborough Sounds (at Havelock, Picton, and at the three Waikawa access points) had not been fishing on the day they were encountered.

The mix of species landed by fishers differed by area (Table 2). Almost all of the observed snapper catch was landed at ramps in Golden Bay/Tasman Bay, with most of the relatively modest snapper catch from the Marlborough Sounds being landed at Havelock. Blue cod were the most commonly caught species, and were landed throughout the year at all eight surveyed ramps, although relatively few cod were landed at ramps in the Marlborough Sounds up to 19 December 2015, which is not surprising as this was the last day of the closed season for blue cod harvesting in these waters. Scallops were also landed at all surveyed ramps during the summer months, although relatively few were landed at Tarakohe in Golden Bay and at Havelock in the inner Marlborough Sounds. Small numbers of rock lobster were landed at all surveyed ramps except Havelock, although relatively few were observed during the quieter winter months.

Table 2: Summary statistics for the creel survey of recreational fishers conducted at boat ramps in Golden Bay, Tasman Bay and the Marlborough Sounds in 2015–16.

		Days surveyed	Hours surveyed	Boats fishing	Boats not fishing	Boats activity unknown	Fishers interviewed	SNA landed	BCO landed	SCA landed	CRA landed
Tarakohe	Closed	18	216	106	0	1	268	216	169	29	1
	Open	20	245	222	35	14	619	284	214	95	10
	Winter	16	153	45	7	1	119	8	81	0	6
Nelson	Closed	18	218	343	158	90	820	728	141	1 404	19
	Open	19	231	426	209	141	1 044	574	163	411	4
	Winter	16	153	97	110	18	251	42	82	0	8
Okiwi	Closed	18	218	250	67	96	718	15	1 149	11 106	147
	Open	20	245	398	110	150	1 102	220	983	4 818	25
	Winter	16	155	79	33	14	208	18	284	0	6
Havelock	Closed	18	226	75	205	2	164	14	10	145	0
	Open	20	243	213	220	6	536	85	313	523	0
	Winter	16	153	43	125	3	99	8	66	0	0
Picton	Closed	18	218	55	244	14	143	0	12	4 514	5
	Open	20	243	101	318	71	287	1	138	2 124	10
	Winter	16	153	33	131	11	71	0	53	0	0
Waikawa marina ramp	Closed	18	218	131	322	16	305	6	64	9 473	28
	Open	20	243	182	556	26	555	0	372	3 482	53
	Winter	16	153	90	237	9	252	0	185	0	0
Waikawa marina marina	Closed	18	218	53	317	33	144	0	3	4 095	5
	Open	20	243	97	335	31	334	4	163	2 953	23
	Winter	16	153	27	111	7	84	7	70	0	2
Waikawa public ramp	Closed	17	208	165	134	49	384	1	63	11 283	62
	Open	20	243	265	382	126	707	0	411	9 054	90
	Winter	16	153	51	117	43	119	1	113	0	0
Golden Bay/ Tasman Bay	Closed	18	652	699	225	187	1 806	959	1 459	12 539	167
	Open	20	721	1 046	354	305	2 765	1 078	1 360	5 324	39
	Winter	16	461	221	150	33	578	68	447	0	20
Marlborough Sounds	Closed	18	1 088	479	1 222	114	1 140	21	152	29 510	100
	Open	20	1 213	858	1 811	260	2 419	90	1 397	18 136	176
	Winter	16	765	244	721	73	625	16	487	0	2
	Total	54	4 898	3 547	4 483	972	9 333	2 232	5 302	65 509	504

The average weight of snapper caught by stationary boat based effort (which can be quantified from the air) was 345 g (20.4%) lighter than the average weight of snapper caught by other fishing methods such as long lining and set netting (which cannot be assessed from the air) (Figure 3). Almost all blue cod were taken by stationary boat based methods, and the average weight of these fish was similar to that taken by methods such as long lining. Most rock lobster and scallops were measured to the nearest 5 mm, despite the fact that interviewers were instructed to measure these species to the nearest millimetre.

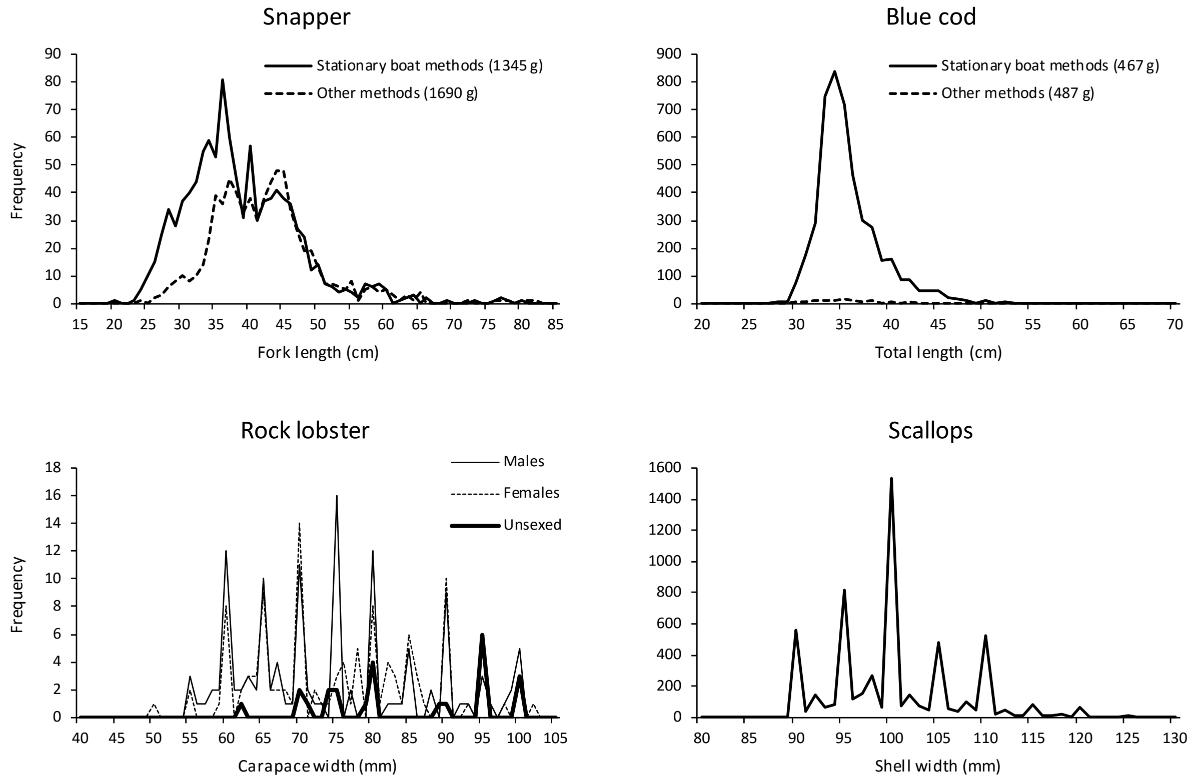

Figure 3: Length frequency distributions of snapper, blue cod, rock lobster and scallops measured during boat ramp interviews.

3.2 Aerial survey

All fishing zones were successfully surveyed from the air on the majority of the 54 randomly preselected survey days, but all flying was cancelled on three of these days and flights were partially curtailed on another seven days, due to high winds and low cloud which made flying unsafe (see outlined boxes in Table 3). The curtailment of survey flights was more common in the Marlborough Sounds, because the funnelling of high winds between ridges and the resulting confused turbulence prevented low altitude flying, and will have also supressed boating activity.

Table 3: Aerial counts of fishing vessels by survey day, by fishing zones (as defined in Figure 1). Most boat counts are not integers, as counts of boats which were not trailer boats, such as launches, were rescaled as trailer boats counts, given the occupancy rate of that boat type relative to that of trailer boats. On some survey days poor weather prevented a complete survey of all fishing zones within an analytical stratum, and an alternative regression based method was used to estimate to number of boats fishing within that stratum on that day (as outlined).

		Analytical strata												
		Golden Bay / Tasman Bay		Inner Marlborough Sounds				Outer Marlborough Sounds						
	Date	CRH	GOB	IQC	KEN	PEI	TEI	ALH	DUE	DUW	OQC	POL	POU	TOC
Summer closed season	12/09/15	34.1	19.0	5.3	1.0	1.0	5.1	2.0	0	4.0	12.1	1.0	2.0	0
	18/09/15	2.0	0	0	0	0	2.0	0	0	0	0.6	2.0	3.0	1.0
	20/09/15	13.0	2.3	–	–	–	–	–	–	–	–	–	–	–
	29/09/15	21.3	2.0	5.0	1.0	1.0	0	0	1.0	4.0	8.0	3.0	0	1.0
	04/10/15	5.0	5.0	2.0	2.0	0	2.0	–	–	–	–	–	–	–
	07/10/15	12.0	9.0	3.0	0.6	1.0	1.0	–	–	–	–	–	–	–
	15/10/15	11.7	7.0	2.0	1.0	0	0	1.0	2.0	0	0	1.0	1.3	2.0
	18/10/15	–	–	–	–	–	–	–	–	–	–	–	–	–
	26/10/15	1.0	79.7	4.0	2.0	1.0	0	1.0	3.0	3.0	5.0	3.0	3.0	6.1
	03/11/15	0	0	0	0	1.0	0	0	0	0	1.0	0	2.0	0
	07/11/15	67.8	115.3	4.0	2.0	3.0	0	1.0	3.9	15.1	3.0	1.0	4.0	4.0
	14/11/15	42.0	150.8	5.0	4.1	3.0	4.0	1.0	2.1	0	13.1	4.1	0	8.0
	17/11/15	0	7.0	3.0	2.0	3.0	0	3.0	0	0	1.0	0	2.0	2.0
	21/11/15	8.0	48.1	3.0	3.0	5.0	3.0	1.0	3.0	0	9.1	3.0	3.0	5.0
	28/11/15	16.0	57.1	2.3	2.0	4.0	2.3	1.0	1.0	1.0	6.6	2.0	4.0	5.0
	04/12/15	3.0	7.4	1.0	4.0	2.0	1.0	2.0	0	1.0	6.1	1.0	2.0	2.0
	13/12/15	6.0	22.7	–	–	–	–	2.0	0	0	2.0	0	6.0	2.5
	17/12/15	12.0	24.7	0	2.1	0	0	0	2.0	0	0	1.0	0	0.7
Summer open season	27/12/15	65.3	192.1	17.4	7.0	7.1	13.0	6.5	10.2	13.0	40.6	19.6	12.1	21.1
	30/12/15	43.1	130.8	26.9	9.0	12.6	18.2	15.7	3.0	9.1	73.6	25.3	7.0	26.6
	04/01/16	6.0	69.2	–	–	–	–	–	–	–	–	–	–	–
	10/01/16	15.0	33.0	0	3.0	1.0	9.1	1.0	1.0	0	5.3	6.0	2.0	3.8
	16/01/16	7.8	10.0	20.9	3.0	10.2	8.1	4.1	0	4.0	19.0	11.1	5.0	17.6
	27/01/16	12.6	11.3	4.0	1.0	2.0	2.0	0	0	1.0	3.0	2.0	0	2
	07/02/16	64.0	98.3	22.1	8.1	12.3	13.1	3.1	1.9	5.6	67.4	21.3	9.0	26.1
	11/02/16	22.0	26.5	2.0	0	5.0	3.1	4.0	9.0	2.1	11.7	7.7	3.0	4.0
	14/02/16	34.3	62.6	15.6	3.0	2.0	4.0	9.1	4.6	6.1	42.1	21.2	11.0	18.7
	17/02/16	–	–	–	–	–	–	–	–	–	–	–	–	–
	26/02/16	16.1	15.9	1.0	1.0	4.0	5.3	2.6	11.9	4.0	7.7	6.0	4.0	9.0
	02/03/16	15.0	13.0	3.0	1.0	2.0	3.0	0	3.0	4.0	6.6	1.0	2.0	5.0
	11/03/16	7.0	12.0	1.0	39.0	4.0	4.0	2.0	2.0	2.0	0	5.0	0	2.7
	12/03/16	66.3	31.4	12.6	12.9	2.0	14.1	3.0	3.0	5.7	35.0	20.9	4.0	5.0
	20/03/16	13.0	35.0	12.1	3.0	3.0	4.7	0	4.0	3.0	7.0	7.4	3.0	6.0
	02/04/16	–	–	–	–	–	–	–	–	–	–	–	–	–
	12/04/16	9.9	2.3	0	0	2.1	0	0	3.1	0	2.0	0	6.0	4.0
	17/04/16	47.3	97.2	8.1	26.1	6.0	4.0	5.9	2.0	2.0	40.6	18.1	6.0	28.2
	22/04/16	24.7	33.3	5.7	3.0	0	3.0	3.2	6.0	4.0	18.4	7.0	5.6	6.2
	23/04/16	31.3	58.0	–	–	–	–	0	8.0	0	47.0	10.1	2.0	16.5
Winter	08/05/16	42.1	16.0	6.1	0	1.0	5.3	2.0	10.1	7.0	14.1	9.6	4.3	14.0
	17/05/16	3.0	0	0	0	1.0	0	0	2.0	1.0	6.1	2.1	3.0	1.0
	22/05/16	5.0	2.0	2.0	2.0	1.0	1.0	2.0	0	0	11.1	3.0	0	4.0
	25/05/16	0	0	0	0	0	0	–	–	–	–	–	–	–
	02/06/16	6.0	2.0	2.0	0	2.0	2.0	1.0	2.0	1.0	11.0	3.0	0	2.0
	06/06/16	27.4	3.7	5.3	0	3.0	3.0	3.0	2.0	4.1	24.2	3.0	2.0	7.0
	11/06/16	1.0	1.0	4.0	0	1.0	1.0	0	5.0	0	1.0	3.0	7.0	5.0
	29/06/16	0	0	0	0	1.0	1.0	0	0	6.0	4.1	1.0	0	1.0
	03/07/16	8.0	0	9.1	0	1.0	2.0	0	3.0	1.0	17.2	6.1	1.0	10.3
	07/07/16	2.0	0	1.0	0	0	1.0	0	0	0	2.0	0	0	0
	17/07/16	0	0	4.6	2.1	4.1	1.0	0	2.0	0	10.1	0	2.0	19.1
	28/07/16	1.0	0	1.0	0	0	1.0	0	0	0	2.0	0	0	0
	13/08/16	1.0	1.0	0	1.6	2.0	1.0	3.0	3.0	0	4.1	1.0	0	2.1
	16/08/16	3.0	2.6	4.0	0	1.0	1.0	2.0	3.0	2.0	13.7	2.1	2.0	3.6
	21/08/16	18.2	2.0	1.0	0	1.0	0	1.0	5.1	9.2	13.3	4.0	0	6.1
	29/08/16	3.0	2.0	3.6	0	2.0	1.0	1.0	1.0	1.0	6.6	0	1.0	4.0
Total		876.0	1521.2	235.9	152.6	121.5	150.4	90.3	129.0	126.3	635.3	250.1	136.4	321.2

Fishing effort tended to be higher on weekends and public holidays, regardless of prevailing weather conditions. Recreational boats were observed fishing in shallow waters throughout the survey area, with almost no stationary fishing effort seen beyond the 40 m depth contour line (Figure 4). Most boats observed in all three analytical strata were classified as trailer boats: 86% of boats fishing in Golden Bay/Tasman Bay (followed by kayaks – 8%); 78% of fishing boats in the Inner Marlborough Sounds (followed by launches – 16%); and 72 % in the Outer Marlborough Sounds (followed by launches – 20%).

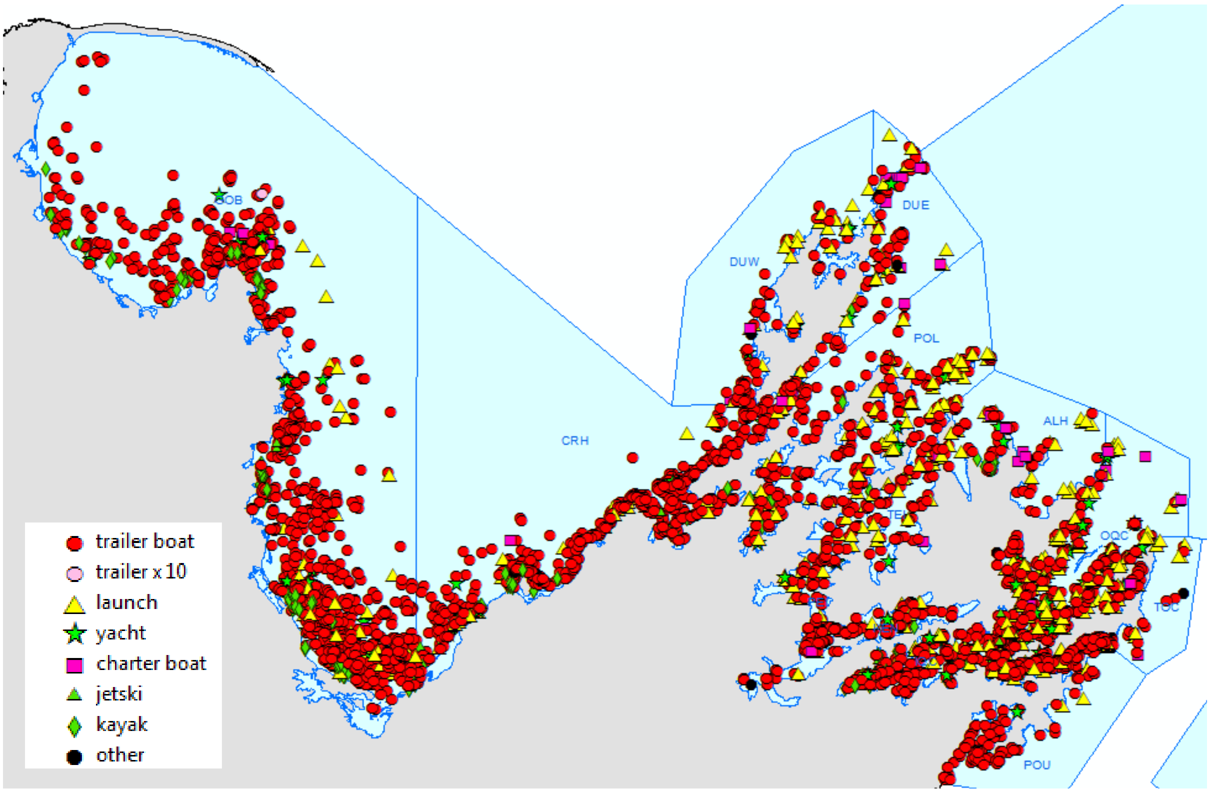

Figure 4: Location of stationary recreational boats considered to be fishing during the aerial survey.

The regressions used to estimate the number of recreational boats that would have been seen fishing during aerial surveys on days when flying was not possible, given the number of interviewed parties claiming to have fished at the time of the flights on flyable days, are given in Figure 5. There is a high degree of correlation between aerial and ramp counts in Golden Bay/Tasman Bay, and for most survey days in the outer Marlborough Sounds, but these two measures of recreational fishing effort are very poorly correlated for the inner Marlborough Sounds stratum. This is probably because many of the boating parties fishing in the Marlborough Sounds would have returned to holiday homes during extended breaks, rather than returning to surveyed boat ramps later that day. This explanation is supported by the fact that the points furthest from the regression line tend to be for days occurring on and around public holidays, such as on the 30 December, when only one interviewed boating party claimed to be fishing in the inner Marlborough Sounds at the time of the aerial survey, yet 40 fishing boats were counted from the air.

Although the levels of uncertainty associated with these bootstrap regressions are likely to be underestimates (because some observations fall well outside of the 95th percentiles derived from the bootstrapped estimates), the error associated with any form of regression will only contribute a very small fraction to the overall variance associated with harvest estimates. This is because the predicted level of effort for most unflown days was low, and any level of variability at this level will have little influence on averaged daily harvest estimates whose magnitudes are largely determined by high effort days when fishing effort was observed and not estimated. These regressions suggest that less than 5.0 % of the effort that took place throughout the survey area during the 54 surveyed days, occurred at times when aerial surveying was not possible: 0.3 % in Golden Bay/Tasman Bay; 6.7 % in the inner Marlborough Sounds; and 10.0% in the outer Marlborough Sounds.

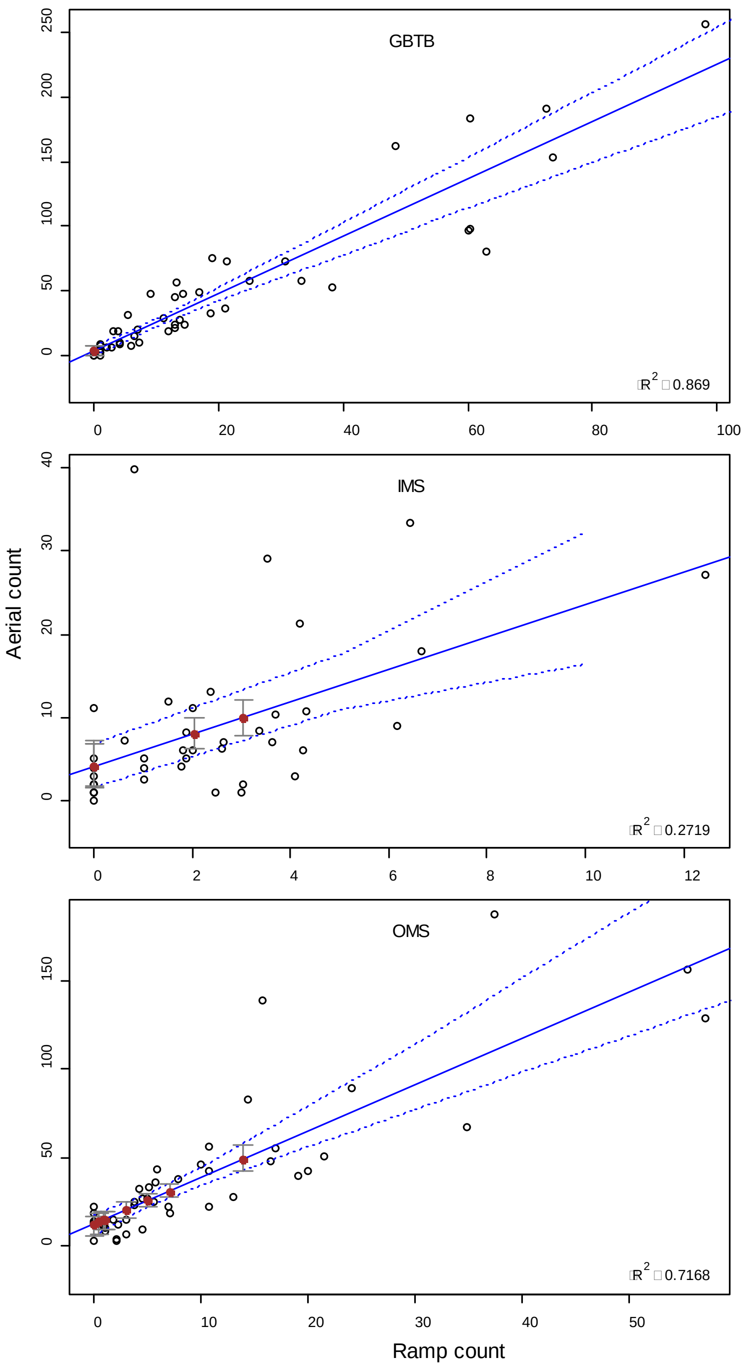

Figure 5: Regressions of aerial counts against counts of interviewed fishing parties (boats) that claimed to have been fishing at the time of the aerial survey, for Golden Bay/Tasman Bay (GBTB), the inner Marlborough Sounds (IMS) and the outer Marlborough Sounds (OMS). These regressions are used to estimate the number of boats that would have been seen from the air on those days when flights were cancelled, when data were only available from concurrent access point surveys. Open circles denote observations on days when both the aerial and access point surveys took place and solid dots with 95% confidence intervals denote predictions of aerial counts for unflown days.

The ratio of aerial counts of fishing boats relative to counts of interviewed boating parties that claimed to have been fishing at the time of the aerial survey also provides an estimate of the proportion of boats fishing on each survey day that returned to surveyed ramps (Figure 6). These plots suggest that, on average, the proportion of boats that returned to surveyed ramps in each area was: 41% in Golden Bay/Tasman Bay; 36% in the inner Marlborough Sounds (30 December notwithstanding), and 20% from the outer Marlborough Sounds. In the busier two areas the proportion of boats using surveyed access points was often far more variable on low effort days.

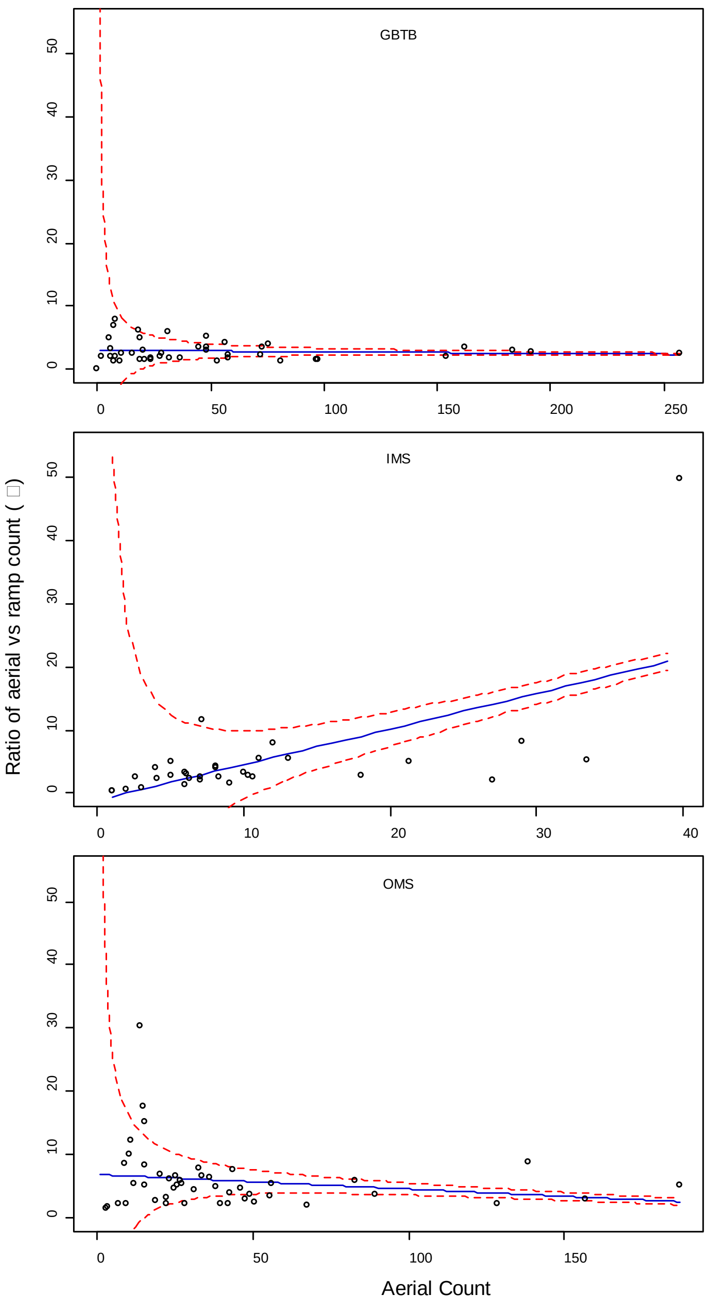

Figure 6: Estimates of the proportion of boats that returned to surveyed ramps on each survey day (ρ), for Golden Bay/Tasman Bay (GBTB), the inner Marlborough Sounds (IMS) and the outer Marlborough Sounds (OMS). These estimates are ratios of aerial counts against counts of fishing parties (boats) that claimed to have been fishing at the time of the aerial survey during access point interviews, which are regressed against each other in Figure 5. Dashed lines denote confidence intervals calculated by the delta method and assuming that the aerial count is measured without error.

3.3 Blue cod and snapper harvest estimates

The finfish most commonly caught by recreational fishers in 2015–16 was blue cod, which was taken throughout the study area. The estimated harvest of blue cod was 74.8 t, which would have accounted for almost all of the recreational harvest from BCO 7 (which also includes most of the west coast of the South Island) over this 12 month period (Table 4). Over 67 % of the estimated blue cod harvest was taken from the outer Marlborough Sounds, with most of the remainder taken from Golden Bay and Tasman Bay. Most of the blue cod harvest was taken over a four and a half month period during the summer, when no spatial closure to blue cod harvesting was in force.

The additional harvest taken by boat based methods not directly assessed by the aerial-access method, such as longlining and set netting, accounted for only 2% of the boat based harvest. Further adjustment of blue cod harvest estimates to allow for fishing from the shore increased the estimated harvest by 3% overall, resulting in a total recreational harvest estimate of 74.8 t. The level of precision associated with the total harvest estimate was reasonable, with a CV of 0.15. Distributions of bootstrap harvest estimates for blue cod by season by region are given in Appendix 1.

Table 4: Estimates of the recreational harvest of blue cod taken from three regions of BCO 7 during 2016–17; during the closed season for blue cod harvesting the Marlborough Sounds, during the summer (1 September 2015 to 19 December 2015), the open summer season (20 December 2015 to 30 April 2016), winter (1 May 2016 to 31 August 2016) and for the full fishing year. Regional harvest estimates are also given by day-type. Coefficients of variation associated with each estimate are given in brackets. Regional aerial-access method estimates are further adjusted to include an allowance for the harvest taken by some forms of fishing which are not readily enumerated from the air (such as longlining, trolling and diving), based on concurrent creel survey data. Further allowance is made for the harvest taken by fishers using shore based methods, based on data provided by the 2011–12 National Panel Survey.

		Closed Summer	Open Summer	Winter	2015–16	Other boat methods	plus other boat methods	Shore methods	plus shore methods
Golden Bay &	Weekends / Pub hols	4.0 (0.28)	8.6 (0.28)	2.4 (0.44)					
Tasman Bay	Midweek days	3.4 (0.33)	2.6 (0.39)	0.0 (–)					
	All days	7.5 (0.21)	11.1 (0.23)	2.4 (0.44)	21.0 (0.15)	3.4%	21.7 (0.15)	0.3%	21.8 (0.15)
Inner	Weekends / Pub hols	0.1 (0.78)	1.8 (0.38)	0.3 (0.47)					
Marlborough	Midweek days	0.0 (–)	0.3 (0.73)	0.0 (–)					
Sounds	All days	0.1 (0.78)	2.1 (0.33)	0.3 (0.47)	2.4 (0.30)	0.5%	2.4 (0.30)	7.2%	2.6 (0.30)
Outer	Weekends / Pub hols	4.0 (0.44)	26.6 (0.35)	5.0 (0.18)					
Marlborough	Midweek days	1.1 (0.66)	5.0 (0.48)	4.8 (0.25)					
Sounds	All days	4.8 (0.37)	31.6 (0.30)	9.9 (0.16)	46.3 (0.22)	1.0%	46.8 (0.22)	7.2%	50.4 (0.22)
	Total	12.4 (0.20)	44.9 (0.22)	12.5 (0.15)	69.7 (0.15)		71.0 (0.15)		74.8 (0.15)

The second most commonly landed species was snapper. The estimated harvest of snapper from the survey area, which would have accounted for almost all of the recreational harvest from SNA 7 during the 2016–17 fishing year, was 83.1 t (Table 4). Over 91% of the estimated snapper harvest was taken from Golden Bay/Tasman Bay, with most of the remainder taken from the inner Marlborough Sounds. Most of the snapper harvest was taken over a four and a half month period during the second half of summer ("open season"), which would have coincided with the snapper spawning season. The relatively low harvest of snapper during the winter months may in part be due to a switch to fishing methods that are more suited to targeting blue cod.

The additional harvest taken by boat based methods that are not directly assessable by the aerial-access method, such as longlining and trolling, was substantial, which accounted for just over half of the boat based snapper harvest in terms of weight, increasing the boat based harvest estimate to 76.3 t. Further adjustment of this estimate, to allow for fishing from the shore, increased the snapper harvest estimate by 9%, to 83.1 t. The level of precision associated with the total harvest estimate was reasonable, with a CV of 0.18. Distributions of bootstrap harvest estimates for snapper by season by region are given in Appendix 2.

Table 5: Estimates of the recreational harvest of snapper taken from three regions of SNA 7 during 2016–17; during the closed season for blue cod harvesting the Marlborough Sounds' during the summer (1 September 2015 to 19 December 2015), the open summer season (20 December 2015 to 30 April 2016), winter (1 May 2016 to 31 August 2016) and for the full fishing year. Regional harvest estimates are also given by day-type. Coefficients of variation associated with each estimate are given in brackets. Regional aerial-access method estimates are further adjusted to include an allowance for the harvest taken by some forms of fishing which are not readily enumerated from the air (such as longlining, trolling and diving), based on concurrent creel survey data. Further allowance is made for the harvest taken by fishers using shore based methods, based on data provided by the 2011–12 National Panel Survey.

		Closed Summer	Open Summer	Winter	2015–16	Other boat methods	plus other boat methods	Shore methods	plus shore methods
Golden Bay &	Weekends / Pub hols	6.4 (0.35)	13.9 (0.24)	0.4 (0.87)					
Tasman Bay	Midweek days	4.3 (0.83)	5.6 (0.43)	0.0 (–)					
	All days	10.7 (0.40)	19.5 (0.21)	0.4 (0.87)	30.5 (0.20)	56.0%	69.4 (0.20)	8.6%	75.9 (0.20)
Inner	Weekends / Pub hols	1.2 (0.69)	2.5 (0.49)	0.0 (–)					
Marlborough	Midweek days	0.0 (–)	0.0 (–)	0.0 (–)					
Sounds	All days	1.2 (0.69)	2.5 (0.49)	0.0 (–)	3.7 (0.40)	2.5%	3.8 (0.40)	4.3%	4.0 (0.40)
Outer	Weekends / Pub hols	0.0 (–)	0.7 (0.84)	0.8 (0.72)					
Marlborough	Midweek days	0.1 (0.89)	0.1 (1.63)	1.5 (0.90)					
Sounds	All days	0.1 (0.89)	0.7 (0.83)	2.3 (0.64)	3.1 (0.51)	0.0%	3.1 (0.51)	4.3%	3.3 (0.51)
	Total	11.9 (0.37)	22.8 (0.19)	2.7 (0.56)	37.4 (0.17)		76.3 (0.18)		83.1 (0.18)

The annual harvest estimates given in Tables 4 and 5 are compared with snapper and blue cod harvest estimates provided by the 2005–06 aerial-access survey of this fishery and the 2011–12 National Panel Survey, in Table 6.

Table 6: Comparison of blue cod and snapper estimates provided by surveys of the recreational fishery in Golden Bay, Tasman Bay and the Marlborough Sounds since 2005–06.

		2005–06 Aerial-Access	2011–12 National Panel	2015–16 Aerial-Access
Snapper	Golden/Tasman Bay	21.8 (0.30)		75.9 (0.20)
	Inner Marlborough Sounds	16.0 (0.20)		4.0 (0.40)
	Outer Marlborough Sounds	4.7 (0.38)		3.3 (0.51)
	Total	42.6 (0.17)	89 (0.17)	83.1 (0.18)
Blue cod	Golden/Tasman Bay	25.1 (0.20)		21.8 (0.15)
	Inner Marlborough Sounds	5.5 (0.28)		2.6 (0.30)
	Outer Marlborough Sounds	117.9 (0.20)		50.4 (0.22)
	Total	148.6 (0.16)	76.8 (0.17)	74.8 (0.15)

3.4 Relative rock lobster and scallop harvest estimates

Two alternative estimates of the recreational harvest of rock lobster taken from the survey area between September 2015 and August 2016 were calculated, given the relative landed weight of snapper and of blue cod observed during creel surveys (Tables 7a and 7b). The rock lobster harvest estimate that was calculated relative to the blue cod harvest (17.70 t) is almost twice that calculated relative to the snapper harvest (9.83 t), but neither estimate is considered to be reliable, for different reasons.

Almost a third of the rock lobster harvest estimate calculated relative to the blue cod harvest was taken in the outer Marlborough Sounds during the closed summer season, but very little blue cod was landed from this area at that time because of the seasonal ban on blue cod harvesting (Table 7a). Many of the fishers who landed rock lobster from this area at this time, who also went rod and line fishing, would have complied with the seasonal ban on blue cod harvesting, while others apparently did not, and the reliability any resulting catch weight ratios based on relative catches of blue cod is therefore uncertain.

Table 7a: Estimates of the recreational harvest of rock lobster from CRA 4 in 2015–16, relative to aerial-access blue cod harvest estimates, given the relative rate at which both species were landed by fishers interviewed during creel surveys conducted seasonally in three regions of BCO 7. Further adjustment has also been made to account for shore based harvesting, given rock lobster catch by fishing platform data provided by panellists during the 2011–12 National Panel Survey.

		Ratio of weight of CRA vs BCO		Aerial BCO harvest estimate		Boat based CRA harvest		NPS % taken from the shore		Total CRA harvest	
Area	Season	ratio	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.	ratio	c.v.	Estimate (t)	c.v.
Golden Bay/	Closed summer	0.18	0.34	7.74	0.21	1.40	0.40	20.6%	0.53	1.76	0.44
Tasman Bay	Open summer	0.06	0.31	11.53	0.23	0.66	0.39	20.6%	0.53	0.83	0.43
	Winter	0.17	0.47	2.45	0.44	0.41	0.67	20.6%	0.53	0.52	0.71
Inner	Closed summer	0.00	–	0.03	0.78	0.00	–	4.5%	0.99	0.00	–
Marlborough	Open summer	0.00	–	2.12	0.33	0.00	–	4.5%	0.99	0.00	–
Sounds	Winter	0.00	–	0.27	–	0.00	–	4.5%	0.99	0.00	–
Outer	Closed summer	1.13	0.38	4.90	0.37	5.55	0.54	4.5%	0.99	5.80	0.55
Marlborough	Open summer	0.26	0.29	31.96	0.30	8.33	0.44	4.5%	0.99	8.72	0.44
Sounds	Winter	0.01	0.97	9.97	0.16	0.07	0.99	4.5%	0.99	0.07	1.00
				70.98	0.15	16.41	0.30			17.70	0.30

The alternative rock lobster harvest estimate, calculated relative to the snapper harvest (Table 7b), is also problematic. Two thirds of the rock lobster landed at surveyed ramps was taken from the outer Marlborough Sounds (321 kg from an all-area total of 480 kg) but only 119 kg of snapper was landed by all interviewed parties who had fished the outer Marlborough Sounds. This means that the ratio of rock lobster landed relative to snapper is high, but poorly estimated given the low incidence of landings of either species in each season (CVs ranging from 0.72 to 1.40). The precision of the seasonal snapper harvest estimates provided by the aerial-access for this area was also low (CVs ranging from 0.64 to 0.89) resulting in a relatively imprecise overall harvest estimate with a CV of 0.59.

Table 7b: Estimates of the recreational harvest of rock lobster from CRA 4 in 2015–16, relative to snapper harvest estimates.

		Ratio of weight of CRA vs SNA		Aerial SNA harvest estimate		Boat based CRA harvest		NPS % taken from the shore		Total CRA harvest	
Area	Season	ratio	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.	ratio	c.v.	Estimate (t)	c.v.
Golden Bay/	Closed summer	0.07	0.36	24.20	0.40	1.65	0.57	20.6%	0.53	2.08	0.60
Tasman Bay	Open summer	0.02	0.33	44.32	0.22	0.89	0.40	20.6%	0.53	1.12	0.43
	Winter	0.66	0.54	0.84	0.87	0.55	1.19	20.6%	0.53	2.16	1.22
Inner	Closed summer	0.00	–	1.19	0.69	0.00	–	4.5%	0.99	0.00	–
Marlborough	Open summer	0.00	–	2.61	0.49	0.00	–	4.5%	0.99	0.00	–
Sounds	Winter	0.00	–	0.00	–	0.00	–	4.5%	0.99	0.00	–
Outer	Closed summer	7.49	1.13	0.11	0.89	0.84	1.77	4.5%	0.99	0.88	1.76
Marlborough	Open summer	4.73	0.72	0.73	0.83	3.43	1.18	4.5%	0.99	3.59	1.18
Sounds	Winter	0.03	1.40	2.29	0.64	0.07	1.80	4.5%	0.99	0.00	1.80
				76.29	0.18	7.44	0.63			9.83	0.59

The lower of these two estimates is similar to that calculated by the alternative method suggested by the Marine Amateur Fisheries Working Group, where estimates of rho calculated for rod and line fishing from stationary boats (which are assumed to be equally applicable to rock lobster fishing methods) are used to scale up the catch of rock lobster landed at survey ramps on each survey day, to account for that landed at all ramps on the same day (Table 8c).

Table 7c: Estimates of the harvest of rock lobster from CRA 4 in 2015–16, calculated by the relative harvest estimation method (from Table 7a and 7b) compared to estimates calculated by using rho (the ratio of the aerial count relative to the number of interviewed parties who claimed to be fishing at the time of the overflight on each survey day) to scale up the combined weight of rock lobster landed at surveyed ramps on each survey day.

		Total CRA harvest estimate				Observed CRA weight scaled by rho	
		vs BCO		vs SNA			
Area	Season	Estimate (t)	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.
Golden Bay/	Closed summer	1.76	0.44	2.08	0.60	0.74	0.73
Tasman Bay	Open summer	0.83	0.43	1.12	0.43	0.57	0.33
	Winter	0.52	0.71	2.16	1.22	0.65	0.52
Inner	Closed summer	0.00	–	0.00	–	0.00	1.21
Marlborough	Open summer	0.00	–	0.00	–	0.00	0.94
Sounds	Winter	0.00	–	0.00	–	0.00	–
Outer	Closed summer	5.80	0.55	0.88	1.76	2.35	0.28
Marlborough	Open summer	8.72	0.44	3.59	1.18	5.41	0.24
Sounds	Winter	0.07	1.00	0.00	1.80	0.21	0.92
		17.70	0.30	9.83	0.59	9.93	0.18

The scallop harvest estimates calculated relative to the blue cod and snapper harvests are also very different in magnitude, being 26.91 t and 10.03 t respectively (Tables 8a and 8b). Neither of these harvest estimates is considered reliable, for different reasons.

The scallop harvest estimate calculated relative to the blue cod harvest estimate is considered to be unreliable because over half of the estimated total scallop catch was taken from the outer Marlborough Sounds during the closed season for blue cod (14.75 t vs 26.91 t). The reliability of scallop/blue cod catch weight ratio estimates for the first half of summer in the Marlborough Sounds is probably low, as they will be undermined by variable and unquantifiable levels of compliance with the ban on blue cod harvesting at this time of year.

Table 8a: Estimates of the recreational harvest of scallops from SCA 7 in 2015–16, relative to aerial-access blue cod harvest estimates.

		Ratio of weight of SCA vs BCO		Aerial BCO harvest estimate		Boat based SCA harvest		NPS % taken from the shore		Total SCA harvest	
Area	Season	ratio	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.	ratio	c.v.	Estimate (t)	c.v.
Golden Bay/	Closed summer	0.24	0.12	7.74	0.21	1.82	0.24	1.12%	0.99	1.84	0.24
Tasman Bay	Open summer	0.12	0.16	11.53	0.23	1.36	0.28	1.12%	0.99	1.37	0.28
	Winter	0.00	–	2.45	0.44	0.00	–	1.12%	0.99	0.00	–
Inner	Closed summer	0.74	0.70	0.03	0.78	0.02	1.71	0.64%	1.01	0.02	1.71
Marlborough	Open summer	0.01	0.70	2.12	0.33	0.02	0.82	0.64%	1.01	0.02	0.82
Sounds	Winter	0.00	–	0.27	–	0.00	–	0.64%	1.01	0.00	–
Outer	Closed summer	2.99	0.24	4.90	0.37	14.65	0.47	0.64%	1.01	14.75	0.47
Marlborough	Open summer	0.28	0.11	31.96	0.30	8.85	0.32	0.64%	1.01	8.90	0.32
Sounds	Winter	0.00	–	9.97	0.16	0.00	–	0.64%	1.01	0.00	–
				70.98	0.15	26.72	0.29			26.91	0.29

The alternative scallop harvest estimate, calculated relative to the snapper harvest is also probably unreliable, because once again, a substantial proportion of the scallop harvest was landed from the outer Marlborough Sounds, from which only 119 kg of snapper was landed during creel survey interview sessions. The reliability of the highly influential yet imprecise scallop to snapper catch weight ratios, coupled with the imprecise seasonal aerial-access snapper harvest estimates, leads to an imprecise and probably unreliable total harvest estimate of 10.03 t (with a CV of 0.58).

Table 8b: Estimates of the recreational harvest of scallops from SCA 7 in 2015–16, relative to snapper harvest estimates.

		Ratio of weight of SCA vs SNA		Aerial SNA harvest estimate		Boat based SCA harvest		NPS % taken from the shore		Total SCA harvest	
Area	Season	ratio	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.	ratio	c.v.	Estimate (t)	c.v.
Golden Bay/	Closed summer	0.09	0.16	24.20	0.40	2.15	0.44	1.12%	0.99	2.17	0.44
Tasman Bay	Open summer	0.04	0.18	44.32	0.22	1.83	0.29	1.12%	0.99	1.85	0.29
	Winter	0.00	–	0.84	0.87	0.00	–	1.12%	0.99	0.00	–
Inner	Closed summer	0.07	0.88	1.19	0.69	0.09	1.21	0.64%	1.01	0.09	1.21
Marlborough	Open summer	0.01	0.71	2.61	0.49	0.02	0.94	0.64%	1.01	0.02	0.94
Sounds	Winter	0.00	–	0.00	–	0.00	–	0.64%	1.01	0.00	–
Outer	Closed summer	19.79	1.09	0.11	0.89	2.21	1.53	0.64%	1.01	2.23	1.53
Marlborough	Open summer	5.02	0.51	0.73	0.83	3.64	1.06	0.64%	1.01	3.67	1.06
Sounds	Winter	0.00	–	2.29	0.64	0.00	–	0.64%	1.01	0.00	–
				76.29	0.18	9.95	0.58			10.03	0.58

These total harvest estimates bracket that calculated by the alternative method suggested by the Marine Amateur Fisheries Working Group, where estimates of rho calculated for rod and line fishing from stationary boats are used to scale up the catch of rock lobster landed at survey ramps on each survey day, to account for that landed at all ramps on the same day (Table 8c).

Table 8c: Estimates of the harvest of scallops from SCA 7 in 2015–16, calculated by the relative harvest estimation method (from Table 8a and 8b) compared to estimates calculated by using rho (the ratio of the aerial count relative to the number of interviewed parties who claimed to be fishing at the time of the overflight on each survey day) to scale up the combined weight of scallops landed at surveyed ramps on each survey day.

		Total SCA harvest estimate				Observed SCA weight scaled by rho	
		vs BCO		vs SNA			
Area	Season	Estimate (t)	c.v.	Estimate (t)	c.v.	Estimate (t)	c.v.
Golden Bay/	Closed summer	1.84	0.24	2.17	0.44	1.60	0.18
Tasman Bay	Open summer	1.37	0.28	1.85	0.29	1.21	0.38
	Winter	0.00	–	0.00	–	0.00	–
Inner	Closed summer	0.02	1.71	0.09	1.21	0.03	0.67
Marlborough	Open summer	0.02	0.82	0.02	0.94	0.29	0.90
Sounds	Winter	0.00	–	0.00	–	0.00	–
Outer	Closed summer	14.75	0.47	2.23	1.53	8.49	0.18
Marlborough	Open summer	8.90	0.32	3.67	1.06	5.98	0.32
Sounds	Winter	0.00	–	0.00	–	0.00	–
		26.91	0.29	10.03	0.58	17.59	0.15

3.5 Catch taken by charter boats

Survey methods such as the Aerial-Access and National Panel surveys offer the only means of quantifying most of the recreational harvest, because amateur fishers are not required to report their catch. The only component of the recreational fishery which is subject to a mandatory reporting regime is the charter boat fleet, who are required to submit Amateur Charter Vessel Activity Catch Returns (ACV-ACRs). Any harvest statistics derived from these returns will be far more comprehensive than any estimates derived from a voluntary subsampling survey of charter boat operators. Another advantage with using ACV-ACR data to quantify the charter boat harvest is that a significant proportion of those fishing from these vessels tend to be visitors from overseas, who are not in frame for a National Panel Survey.

An extract from MPIs ACV-ACR database was therefore used to quantify the charter boat catch taken from Golden Bay, Tasman Bay and the Marlborough Sounds, which has not been accounted for in any of the estimates given above. Charter boats operating in these waters in 2015–16 reported harvests of: 520 kg of blue cod, 48 kg of snapper, 65 kg of scallops and 50 kg of rock lobster. Of these, only the charter boat harvest of blue cod makes a substantive difference to the harvest estimates provided by this programme, raising the harvest estimate for this species from 74.84 t to 75.36 t.

4. DISCUSSION

To date there have been only two other onsite recreational harvest estimation surveys conducted off the upper South Island. An access point survey of the recreational scallop fishery in Golden Bay and Tasman Bay in 2003–04 (Cole et al. 2006), and an aerial-access survey of the recreational finfish fishery in Golden Bay, Tasman Bay and the Marlborough Sounds in 2005–06 (Davey et al. 2008).

The methods used in this survey were similar to those used in 2005–06, but significant improvements were made to the survey design to address shortcomings with the previous survey. These changes to the survey design were also influenced by the findings of a pilot survey of the FMA 7 recreational fishery, conducted in 2014–15 (Hartill et al. 2015a).

Creel survey interviews were conducted at three additional access points as part of this survey, which should have improved the power of the regression used to estimate aerial counts of fishing boats in the outer Marlborough Sounds on unflown days, and generally increased the precision and accuracy of harvest estimates for this area. The number of survey days was also increased from 40 to 54 days, with the minimum number of days surveyed in any given temporal stratum increased from five to eight days. This increase in temporal sampling intensity should have reduced the likelihood of a non-representative sample of survey days being drawn at random, which can lead to biased harvest estimates (Hartill & Edwards 2015). The benefits of increasing the overall number of survey days would have been partially offset by the need to increase the number of temporal strata from four to six, to address the introduction of the closed season for blue cod harvesting in the Marlborough Sounds on 1 September 2012. The other major improvement to the 2005–06 survey design was the adoption of a more efficient and consistent flight route, so that quicker progressive boat counts were made at times that were closer to the expected time of peak fishing effort in each area.

The blue cod and snapper harvest estimates provided by this survey are therefore considered to be more reliable than those provided by the 2005–06 aerial-access survey, and are probably at least as reliable as those provided by the 2011–12 National Panel Survey (Wynne-Jones et al. 2014). The 2011–12 National Panel Survey BCO 7 harvest estimate was based on 191 panellists reporting 622 fishing events where blue cod was caught, and the SNA 7 estimate was based on 137 panellists reporting 378 snapper harvesting events. While the precision of those estimates was reasonably precise, the ideal minimum number of panellists required to inform a harvest estimate is 300 (Andy Heinemann, National Research Bureau, pers comm.).

The blue cod and snapper harvest estimates provided by this survey are of a very similar magnitude to those provided by the 2011–12 National Panel Survey. While this similarity suggests that there has been little change in levels of recreational harvesting from these fish stocks in recent years, a comparison of finer scale regional harvest estimates provided by the 2005–06 and 2015–16 aerial-access surveys indicates a more marked change in these fisheries.

A far greater proportion of the harvest from SNA 7 is now taken from Golden Bay/Tasman Bay, where the estimated recreational snapper harvest has increased more than threefold, while the snapper harvest from the inner Marlborough Sounds has decreased fourfold since 2005–06. The increase in the recreational harvest of snapper from Golden Bay/Tasman Bay (and consequently for all of FMA 7) is not surprising, as it mirrors a recent increase in a standardised bottom trawl CPUE index for SNA 7 (Langley 2013), and anecdotal reports by recreational fishers of significant increases in snapper catch rates. This increase in abundance in Golden Bay and Tasman Bay would have been largely due to the recruitment of a very strong 2008 year class and strong but lesser 2011 year class, which respectively accounted for 69% and 23% of all fish aged from the bottom trawl fishery in 2013–14 (Parker et al. 2015). The integration of this information in the most recent assessment of SNA 7 suggested that the biomass from this stock had increased approximately fourfold (Langley 2015), but it is important to note that the abundance indices and catch-at-age data offered to this model mostly came from commercial fisheries operating in Golden Bay and Tasman Bay (Adam Langley, Trophia, pers comm.).

The blue cod harvest from the Marlborough Sounds has halved in recent years, but there has been relatively little change in the blue cod harvest from Golden Bay and Tasman Bay over the past 10 years. Some of the differences in levels of harvesting of these species will be due to changes to blue cod size and daily bag limits, and the introduction of a seasonal moratorium on blue cod harvesting in the Marlborough Sounds, which will have also influenced spatial distribution and intensity of recreational fishing effort.

Alternative rock lobster and scallop harvest estimates have also been calculated, relative to aerial-access snapper and blue cod harvest estimates, but none of these is considered reliable. This is because not enough landings of snapper and blue cod were encountered during creel surveys at some times, and in some areas, where appreciable numbers of scallops and rock lobster were encountered during creel survey interviews. Estimates of species catch ratios were therefore relatively imprecise, and some of these were combined with low stratum specific snapper or blue cod harvest estimates, which were also imprecise. In the case of the scallop and rock lobster harvest estimates calculated relative to blue cod harvest estimates, the seasonal closure of blue cod harvesting in the Marlborough Sounds meant that very few blue cod were landed in the spring and early summer, when both of these shellfish species were commonly landed at surveyed boat ramps. The scallop and rock lobster harvest estimates calculated relative to the snapper harvest estimates in the Marlborough Sounds were also undermined by the fact that landings of snapper from these waters are far less frequent than in 2005–06. The only subset of these estimates that may be reliable are the scallop harvest estimates calculated for Golden Bay/Tasman Bay, as they are of a similar magnitude regardless of whether they were calculated relative to snapper or blue cod harvest estimates in this area.

An alternative method of estimating rock lobster and scallop harvests was suggested when the relative harvest method estimates were presented to the Marine Amateur Fisheries Working Group, but the estimates this approach produced are probably no more reliable. This is because, with this method, it is necessary to assume that daily estimates of rho calculated for stationary boat based rod and line fishing are equally applicable to other forms of fishing effort, which is unlikely to be the case. This is because fishing for scallops and rock lobster is not as widespread as fishing for snapper and blue cod, and the spatial distribution of launching points for fishers targeting these shellfish species may differ considerably from that of fishers targeting more ubiquitous finfish species.

This survey therefore provides recreational snapper and blue cod harvest estimates for the 2015–16 fishing year which we consider to be reasonably reliable (but not for rock lobster and scallops), in addition to those provided by the 2005–06 aerial-access and 2011–12 National Panel Survey. Further annual recreational harvest estimates for the BCO 7 and SNA 7 fish stocks should be available from a National Panel Survey planned for the 2017–18 fishing year. There is increasing evidence to suggest, however, that there can be considerable interannual variability in levels of recreational harvesting, because variable weather can suppress fishing effort at times, and because of fluctuations in the availability of fish to recreational fishers, who tend to fish close to the shore. Two web camera systems have therefore been established overlooking the boat ramps in Nelson and Waikawa as part of this programme, and the ramp traffic data provided by these, and that collected during associated creel surveys, should provide an ongoing means of monitoring trends in recreational harvesting from these fisheries, in a more consistent and continual fashion.

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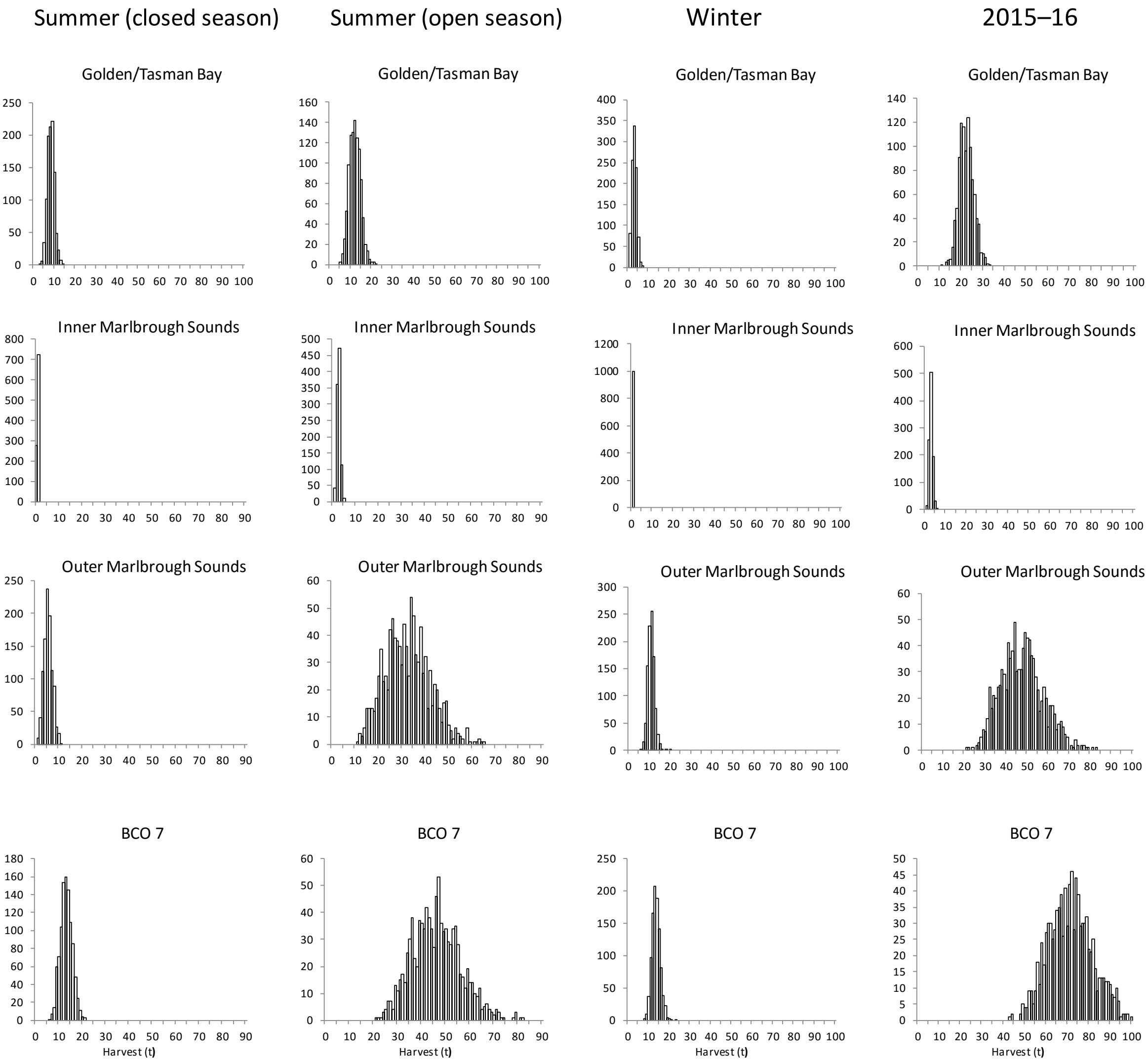
APPENDIX 1: Distribution of bootstrap estimates of the recreational blue cod harvest from three regions of BCO 7 in 2015–16 during three seasonal strata, and for all three combined.



APPENDIX 2: Distribution of bootstrap estimates of the recreational snapper harvest from three regions of SNA 7 in 2015–16 during three seasonal strata, and for all three combined.