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Monitoring the amateur fishery for blue cod, sea perch, and rock lobster in North Canterbury–Kaikoura; third boat ramp survey, 2012–13

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EXECUTIVE SUMMARY

Kendrick, T.H.; Hanley, G. (2021). Monitoring the amateur fishery for blue cod, sea perch, and rock lobster in North Canterbury–Kaikōura; third boat ramp survey, 2012–13.

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This survey monitored changes in recreational catch rates and changes in harvest size distribution for blue cod and sea perch in the North Canterbury–Kaikōura area by surveying boat ramps at Motunau and Kaikōura and drawing comparisons with previous surveys done in 2003 and in 2009.

The emphasis of the survey design was on obtaining total coverage of line fishing effort along the coast targeted at blue cod and/or sea perch, as well as obtaining length measurements from the harvest of both species. Harvest rate estimates in numbers of fish per vessel-hour were used to estimate total removals for each species.

The 2013 survey was expanded beyond the January to April summer period to monitor amateur catches for the entire 2012–13 fishing year. It was also expanded to include the amateur catch of rock lobster for the first time. Lobster harvest estimates were based on catch per trip.

New equations were used in this study to estimate the total harvest and its standard errors from estimates of daily harvest, in line with what is currently done for other boat ramp surveys in New Zealand. Estimates of total harvest for 2003 and 2009 have been reworked resulting in similar point estimates but much smaller standard errors. They will therefore vary from what has been published previously, though without altering any conclusions drawn.

The estimates of total effort describe a further large (more than 50%) increase in private vessel effort targeted at blue cod or sea perch at Kaikōura between 2009 and 2013, particularly on weekends, and a smaller increase at Motunau, mostly on weekdays. The relative importance of the two areas (79% and 21% respectively) confirms a continuing shift in the relative importance of effort towards Kaikōura. The majority of vessels launched from Kaikōura boat ramps, however, were fishing for lobster, generally by potting, and an increased proportion of vessels launched from Motunau in 2013 were targeting lobster, mostly by diving. We found no evidence that refugee fishers from the Marlborough blue cod fishery were adding to the fishing pressure at Kaikōura or Motunau.

Average catch rates of legal size blue cod at Kaikōura were unchanged from 2009 at less than one fish per vessel per hour but had declined significantly at Motunau from just over four fish per hour in 2009 to just over three per hour in 2013.

The proportion of the catch of blue cod below legal size appears to have increased at Kaikōura and private fishers continue to exercise their own minimum size and to voluntarily release legal fish. The increase in the number of sub-legal fish, when considered alongside the increase in the total (but not in the legal) catch per hour, may indicate an imminent recruitment to the fishery or at least a return to a more normal situation (than in 2009). The size distribution of retained blue cod caught at Motunau was unchanged from 2009.

Catch rates of sea perch continued to decline at both locations but not significantly, and the size distribution of the harvest points to modes of smaller fish than have previously been seen, although average size had not changed significantly for the private fleet. Anglers have responded by releasing a greater proportion of their catch than in previous surveys. A large and significant decline in average fish size kept on charter vessels is more likely to be an artefact of the small sample in 2013 (30 trips) and changes in the fleet from year to year, than in the underlying population of sea perch.

Comparisons for the January to April period with previous surveys indicate an increase between 2009 and 2013 of the private vessel harvest of blue cod by almost 5% (in numbers) and 15% in biomass. The harvest of sea perch increased by 21% in numbers and 25% in biomass. Few trends in charter fishing could be described in this transitional year (from collecting logbook data to analysing Amateur Charter Vessel Activity Catch Return returns).

The estimates of total amateur harvest (including charter fishing) for the fishing year 2012–13 were: more than 41 000 blue cod (converting to almost 32 t), almost 77 000 sea perch (converting to more than 32 t), and more than 80 000 lobster (converting to almost 54 t).

The authors would to thank Te Korowai o Te Tai o Marakura for their support with this project. The monitoring of recreational fishing has been, and is, critical to the sustainable management of the key recreational species of blue cod, sea perch, and rock lobster. The Kaikōura Marine Management Act 2014 came into force in early August 2014 and specific rules have been introduced for each of the species targeted in this project.

1. INTRODUCTION

National diary surveys of marine recreational fishing have found blue cod (*Parapercis colias*) to be the third most frequently landed species nationally (behind snapper and kahawai), and the most important recreational finfish in the South Island (Ministry of Fisheries 2010). Surveys undertaken in 1992 and 1996 put the recreational harvest along the east coast of the South Island, in BCO 3, at between 175 and 245 t (Bradford et al. 1998). In addition, commercial fishers in this area land about 150 to 180 t of blue cod annually. Blue cod is also an important species for Maori customary fishers. About 80% of the recreational blue cod harvest in BCO 3 is taken in Otago waters off Moeraki, Karitane, and Taieri Mouth; however, blue cod is still a very important species in the northern part of BCO 3. Although blue cod is distributed throughout New Zealand, tagging studies have shown it to exhibit little movement from home ranges (Carbines 2001). Consequently, there are likely to be many, largely independent, sub-stocks of blue cod, potentially rendering this species susceptible to localised depletion.

Commercial fishing

This is a shared fishery with both species also taken commercially. Blue cod in BCO 3 is largely caught by potting, and sea perch in SPE 3 is a target and bycatch of the mixed species inshore bottom trawl fishery. BCO 3 catches have consistently exceeded the TACC of 163 t by about 5% since 2002–03. Commercial sea perch catches have declined from over 1000 t in 1995–96 to 328 t in 2008–09 and have not been constrained by the TACC of 1000 t (Ministry of Fisheries 2010).

The commercial fishery for blue cod in northern BCO 3 is monitored using potting surveys. Fishery independent surveys of blue cod in North Canterbury (part of BCO 3) in 2004–05 (Carbines & Beentjes 2006) and in 2008 (Carbines & Beentjes 2009) used standardised cod pots, and described an overall 44% decline in catch rates of legal size blue cod in Motunau between 2005 and 2008.

Abundance of sea perch in SPE 3 was monitored under an Adaptive Management Programme (AMP) in trawl tows targeted at sea perch, red cod, barracouta, or tarakihi (Ministry of Fisheries 2010). A target bottom trawl fishery centred on Kaikōura effectively ceased when the main participant withdrew from the fishery in 2002–03. Since then, the fishery has largely operated further south in Statistical Areas 020 and 022.

Recreational fishing

Some recreational fishers are concerned about the stocks of blue cod in the northern part of BCO 3. The area of reef is limited by a narrow continental shelf, and a series of troughs and canyons that come close inshore at Kaikōura. As a consequence of anecdotal information given to the Ministry of Fisheries Review of Sustainability Measures for 2000–01, the recreational bag limit for blue cod was lowered in December 2000 for the northern part of BCO 3 (from the Waimakariri River to Clarence Point). The current amateur fisheries regulations for North Canterbury–Kaikōura include a Minimum Legal Size (MLS) of 30 cm and a Maximum Daily Limit (MDL) of 10 fish. In 2003, the MDL in an adjacent Fishtock, BCO 7 (Marlborough Sounds), was reduced to 3 fish due to sustainability concerns and from 1 October 2008 the enclosed waters of Marlborough Sounds were temporarily closed to all recreational fishing for blue cod (expiring on 1 October 2012 unless removed earlier). Kaikōura is only 90 minutes away by road from Blenheim and is a viable alternative for fishers so that the closure is considered to have increased pressure on the Kaikōura fishery.

There are also concerns about the stocks of sea perch (*Helicolenus percoides*) in the northern part of SPE 3. Fishing pressure is said to have increased in the Kaikōura area, partly due to an increase in the number of charter boats and partly from perceived shifts in recreational effort from Motunau, and more recently from the Marlborough Sounds, to Kaikōura. Sea perch are seldom targeted by recreational fishers but are caught in large numbers. Some are used for bait, and most have historically been discarded, but they are gaining favour as a table fish. There is no amateur fisheries regulated MDL for sea perch in this area.

Blue cod and sea perch are caught almost exclusively by line fishing from vessels. The Kaikōura area is serviced by six main boat ramps and the North Canterbury area by one ramp at Motunau, so there is considerable potential for monitoring a significant proportion of the total recreational effort and harvest using boat ramp surveys. Many of the locals from Kaikōura are retired and fish when the weather is suitable whatever the day of the week, but at Motunau there is a more pronounced difference with higher effort recorded on weekends than on weekdays. The tidal bar at Motunau concentrates returning boats over a short time period so the timing of sampling at that ramp needs to be determined by tide times rather than being allocated randomly. A considerable proportion of private vessel boat trips target rock lobster and that needs to be accounted for when estimating relevant total effort.

Previous work

In this research, changes in harvest rates and lengths of the two key target species, sea perch and blue cod, are monitored by repeating a survey designed and carried out in 2003 (Hart & Walker 2004).

The 2003 survey undertook boat ramp surveys on 45 sample days and analysed logbooks from six charter vessels. The results included estimates of total recreational effort and of total harvest for the four months January to April 2003, as well as estimates of harvest rate (kg/hour) and size distribution for blue cod and for sea perch in four parts of the fishery: Kaikōura private vessels, Kaikōura charter vessels, Motunau (North Canterbury) private vessels, and Motunau charter vessels. This study provided the first baseline statistics for this fishery and established a repeatable design suitable for monitoring any changes in the patterns of exploitation or in the availability or average size of the key species.

For charter vessels, the 2003 study was able to compare harvest rates and fish lengths with results from a previous small-scale programme that ran from October 1999 to February 2001, and which obtained data from 388 trips on three vessels. Tentative comparisons of blue cod harvest rates and sizes were also able to be made with the national diary surveys of marine recreational fishing undertaken in 1992 and 1996 (Bradford et al. 1998) but those surveys failed to provide good estimates of the recreational sea perch harvest due to problems with species identification and incomplete records.

The 2003 study also characterised angler demographics and presented a power analysis describing the sampling effort required to achieve each estimate at various levels of precision. It concluded that monitoring the recreational blue cod and sea perch fishery in the North Canterbury–Kaikōura area with a bus route/access sampling design of 35 sample days (between January and April) would yield at least 300 estimates of harvest rate required to detect a 20% decline in harvest rate (numbers per vessel-hour) and would yield more than the minimum 150 measured fish (per species) required to detect changes of 1 cm or more in mean fish size.

The main result of note from the 2003 survey was the significant difference in mean size of blue cod for private vessels between Kaikōura and Motunau. On average, blue cod caught from Kaikōura weighed 1.1 kg compared with 0.7 kg from Motunau. The size frequency distribution for blue cod caught by Motunau private vessels was knife-edged above the MLS, which can be a sign of a heavily exploited stock. The net result of this is that even though it was estimated that almost twice as many blue cod were harvested from Motunau compared with Kaikōura, the estimated harvest in tonnes was very similar. This size difference was also observed in the 1996 surveys, suggesting that exploitation could have been quite high for some time in Motunau. Hart & Walker (2004) noted that if exploitation at Kaikōura continued to increase, as was quite likely, a similar response in Kaikōura blue cod populations might be detected in the future.

Total private vessel effort increased by 100% at Kaikōura and by 20% at Motunau between 2003 and 2009. There was a shift towards more weekday fishing at Kaikōura. Effort expanded into a third boat ramp at Kaikōura in 2009 (two boat ramps accounted for 80% of effort in 2003), and the overflow from parking areas meant that more trailers were removed off-site, with a specific correction required to be made for this (which was not necessary in 2003).

The mean size of fish retained from private vessels at Kaikōura in 2009 was smaller (significant at p=0.05) by about 4 cm for blue cod and by over 3 cm for sea perch. There was no change in fish size at Motunau. In 2003, retained blue cod from Kaikōura were considerably larger than those from Motunau, but that differential had disappeared by 2009. In both areas, the proportion of legal blue cod in the harvest was greater in 2009 by about 10%. In Kaikōura this compensated fishers somewhat for a decline in the total catch per trip, and in Motunau it manifested as a significant increase in the catch rate of legal size fish despite no significant change in total catch.

The estimates of total harvest retained by the private vessel fishers during the four month period January to April 2009 suggested there was a 60% increase in the number of blue cod taken between 2003 and 2009, corresponding closely with the estimated increase in effort, and converting to a 40% increase in biomass because of the decline in fish size at Kaikōura. The number of sea perch taken increased by 30% and equated to a 10% decrease in the biomass removed because of the smaller fish size in Kaikōura in 2009.

The overall objective of this research project was to monitor the marine amateur fishery for key species in the North Canterbury–Kaikōura area from 01 October 2012 through 30 September 2013.

There were three specific objectives;

1. To monitor harvest rates of key species in the North Canterbury–Kaikōura area marine amateur fisheries.

2. To monitor size composition of the harvest of key species in the North Canterbury–Kaikōura area marine amateur fisheries.

3. To estimate the harvest of key species in the North Canterbury–Kaikōura area marine amateur fisheries.

2. METHODS

The boat ramp surveys carried out for this study aimed to achieve comprehensive coverage of private vessel recreational fishing in the Kaikōura and North Canterbury regions for January to April inclusive for comparison with previous surveys in 2003 and 2009. The restricted access points along these coastlines makes it possible to survey all boat ramps, and the bus route method (Pollock et al. 1994) was employed to monitor the six boats ramps in Kaikōura randomly within a day in proportion to the effort expended from them. Sampling at the more remote Motunau ramp (North Canterbury) was done over the entire day, or at least over the tidal range for which the bar makes it accessible.

Surveyors initiated an interview for each boat retrieved. They obtained catch rate measures, both total and retained (harvested), for all species caught, and length measurements of the harvest for the two key species (blue cod and sea perch) along with ancillary information to describe fishing effort. Harvest rates, fish size, and total removals are based on retained catch which could be seen by the surveyors, whereas estimates of total catch, legal catch, and discards (both legal and sub-legal) are based on fisher recall and are subject to bias.

The survey also included counts of trailers and observations of vessel launches and recoveries at each ramp to estimate total daily effort (vessel-hours) in the area stratum. A correction for trailers that were removed off-site (for lack of parking space) was necessary in 2009 and 2013. Total daily effort was also corrected upwards for trips that started earlier in the day than sampling did, and downwards to account for the proportion of boats launched for reasons other than line fishing for blue cod (BCO) or sea perch (SPE).

Total daily effort was multiplied by the day's average retained catch per vessel-hour (ratio of means) to obtain estimates of daily removals in the area stratum which were then scaled up by the number of days in a stratum to obtain estimates of total removals. The variance of the estimates is calculated from the variance of these daily totals. This represents a departure from the methodology used in the previous studies, which incorporated the variances of catch and of duration at interview resolution, but is more consistent with other surveys of recreational harvest currently being reviewed by the Marine Amateur Fishing Working Group (MAFWG).

The boat ramp survey logbook and session cover sheet designed for this project is attached in Appendix 2. The design closely follows the *rec_dat* database format.

This report describes the third survey (starting in October 2012) which expands coverage to an entire fishing year and includes rock lobster among the target species. Surveying for the period January to April is intended to continue the time series and allow comparisons to made with the previous surveys, but is extended to dawn starts to intercept fishers returning from checking their lobster pots, and extended to a full year to allow seasonal trends to be described and total harvest of the three key species to be estimated for the fishing year 2012–13.

Charter vessels are not monitored in the boat ramp survey, but fish measurements were obtained by observers who opportunistically participated in 30 charter vessel trips. Catch and harvest rates are obtained from MPI charter returns which have been mandatory since October 2012. Because the number of fishers on these boats (up to ten) is greater than for the typical private vessels, they are not included in the strata used for daily effort estimates. The catch and harvest rates achieved, and the average size of fish retained, also determine that charter fishing belongs to a separate stratum from private vessel fishing.

2.1 Spatial and temporal stratification

Estimates of catch rates and fish size were required for the two key species in two distinct areas (Kaikōura and Motunau). Total effort and total harvest were also estimated for the private vessel fleet over the whole region. Sampling effort was stratified by day type (weekends and weekdays) and by boat ramp in proportion to the fishing effort expended in each. Total targeted effort estimated from the previous survey was used to stratify sampling by area and by weekends and weekdays (Table 1). Weekdays in the first week of January and Easter Friday and Monday were included in weekend strata due to their holiday status. Competition days were avoided, because they make up a stratum of their own.

Hart & Walker (2004) accessed data from the 1992 and 1996 Recreational Surveys from the MFish database "rec_dat" that suggested that a sampling effort allocation of 23% at Kaikōura and 77% at Motunau would have best reflected fishing effort at that time (during the 1990s). The allocation they actually used in 2003 was 60% Kaikōura and 40% Motunau to better reflect the larger area fished by vessels operating along the Kaikōura coastline.

Analysis of the total effort estimates from the 2003 survey confirmed that there had been a marked shift in effort into northern areas with 72% of recreational effort for the region estimated to have been expended from Kaikōura, and in 2009 this had increased slightly to 74% (Table 1).

The allocation of sampling effort on Kaikōura in 2013 was set to 66%, and proportional allocation between weekends and weekdays was retained at near the 60% weekends and 40% weekdays, and 85% and 15% respectively for Motunau. The final sampling allocation by location and day type is given in (Table 2). Days in each stratum were assigned dates randomly.

It was anticipated that 300 interviews could be obtained in each of Kaikōura and Motunau during January-April with 59 days of sampling (based on the intercept rates achieved in 2009), allocated between area and day type strata proportionate to effort estimated to have been expended in 2009. The

tidal bar at Motunau concentrates returning boats over a short time period so intercept rates are higher than those experienced at Kaikōura. For each day of sampling at Kaikōura, the wait times at each boat ramp were set proportional to the number of relevant interviews obtained per hour of sampling during the 2009 survey and are given in Table 3. This represented a shift of sampling effort towards more time spent at Boat Harbour and less at the two South Bay ramps than previously (Table 3).

A power analysis (Table 4) that re-sampled catch rates obtained in 2009 for each species in each area, concluded that even at 300 interviews in each area, the *de facto* objectives will only be achieved for the main species in each area (SPE in Kaikōura and BCO in Motunau) and not for the less abundant species.

Table 1: Effort weighting (percent vessel-hours), based on distribution of recreational fishing effort in 2009, proportionate allocation of days in 2009, and intercept rates (relevant interviews per day) achieved in 2009, from Kendrick et al. (2011).

Effort in Jan-Apr 2009		%	%	Intercept
Area	Day type	by area	by area day	rate
Kaikōura	Weekend		45	9.1
	Weekday	74	55	6.5
Motunau	Weekend		85	17.9
	Weekday	26	15	1

Table 2: Proposed sampling in January to April 2013 to achieve 300 interviews in each area, maintaining splits by area and day type determined by effort estimated in 2009, and the anticipated number of harvest rates estimates for 2013.

Proposed sampling in Jan-Apr 2013		Days		%		anticipated
Area	Day type	by	by area	by area	by area	interviews
Kaikōura	Weekend		18		45%	160
	Weekday	39	21	66%	55%	139
Motunau	Weekend		17		85%	304
	Weekday	20	3	34%	15%	3
		59				606

Table 3: Effort weighting (proportion) based on relevant (BCO/SPE) interviews per hour obtained during the 2003 and 2009 surveys. 2009 weightings were used to apportion allocation (minutes) in 2013 of sampling (wait) time among boat ramps at Kaikōura.

Boat Ramp	2003 Effort Weighting	2009 Effort weighting
Boat Harbour	0.02	0.25
Pier Slipway	0.02	–
Armers Beach	0.08	0.06
Public Ramp	0.45	0.40
Boat Club	0.35	0.27
Barney's Rock	0.08	0.01
All	1.00	1.00

2.2 Number of interviews required

An interview was initiated for each vessel retrieval observed, and then coded depending on the outcome. Whether or not the trailer had been kept off-site was noted. Vessels that were not relevant to the survey were noted (e.g., those used for water skiing).

The 2009 survey obtained 430 valid interviews (232 from Kaikōura and 198 from Motunau) and highlighted differences in species composition between the two subareas (Kaikōura and Motunau) as well as different trends in harvest rates. That study attempted to describe changes in catch rates for each species in the two area strata separately.

A power analysis was done using harvest rates for blue cod and catch rates of sea perch (because fish of any size can legally be taken), for the two areas separately. Results showed that 300 valid interviews in each area would be adequate to detect a 20% change in catch rate of the dominant species (SPE in Kaikōura, BCO in Motunau), but not of the less prevalent species in each area (Table 4).

Table 4: Power (1-β) of simulated tests to detect specified reductions (10–35%) in harvest [left], or total catch [right] rates of blue cod (*Parapercias colias*) and sea perch (*Helicolenus percoides*), at Kaikōura [upper] and Motunua [lower] at various sample sizes. Tests where power is greater than the conventionally accepted value of 0.8 are shaded.

Harvest rate reduction (%)							Sample size (n)					
Kaikōura	150	200	250	300	350	400	150	200	250	300	350	400
Blue cod (retained)							All blue cod caught					
10%	0	0	0	0	0	0	0	0	0	0	0	0
15%	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0.00	0.01	0.17	0.65	0	0	0.01	0.19	0.77	0.99
25%	0.00	0.12	0.71	0.99	1	1	0.02	0.52	0.99	1	1	1
30%	0.46	0.98	1	1	1	1	0.85	1	1	1	1	1
35%	0.98	1	1	1	1	1	1	1	1	1	1	1
Sea perch (retained)							All sea perch caught					
10%	0	0	0	0	0	0	0	0	0	0	0	0
15%	0	0	0	0.04	0.33	0.86	0	0	0.11	0.658	0.981	1
20%	0.039	0.553	0.988	1	1	1	0.388	0.98	1	1	1	1
25%	0.958	1	1	1	1	1	1	1	1	1	1	1
30%	1	1	1	1	1	1	1	1	1	1	1	1
35%	1	1	1	1	1	1	1	1	1	1	1	1

Harvest rate reduction (%)							Sample size (n)					
Motunau	150	200	250	300	350	400	150	200	250	300	350	400
Blue cod (retained)							All blue cod caught					
10%	0	0	0	0	0	0	0	0	0	0	0	0
15%	0	0	0.00	0.05	0.24	0.64	0	0.02	0.17	0.58	0.93	0.996
20%	0.07	0.46	0.93	1	1	1	0.42	0.95	1	1	1	1
25%	0.87	1	1	1	1	1	0.995	1	1	1	1	1
30%	1	1	1	1	1	1	1	1	1	1	1	1
35%	1	1	1	1	1	1	1	1	1	1	1	1
Sea perch (retained)							All sea perch caught					
10%	0	0	0	0	0	0	0	0	0	0	0	0
15%	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	0	0	0
25%	0	0	0	0	0.04	0.28	0	0	0.00	0.02	0.18	0.58
30%	0	0.01	0.20	0.70	0.97	1	0.01	0.05	0.39	0.87	0.991	1
35%	0.04	0.52	0.94	1	1	1	0.18	0.75	0.99	1	1	1

2.3 Expanding the survey to cover the full year

A further 45 days expands the design out to include the rest of summer (Oct 2012–Dec 2012), and an additional 36 days covered winter at 0.5 the summer intensity (Table 5). The data collected over the January-April period are analysed separately and the results used to draw comparisons with the previous

surveys in 2003 and in 2009. Harvest rate information outside this period was used for estimating the total harvest of CRA, BCO, and SPE for the 2012–13 fishing year.

Table 5: Sampling allocation for the fishing year 2012–13.

Dates	Season	Area	Day type	Days in stratum	Days sampling	Sampling intensity
Oct-Dec	Summer	Kaikōura	Weekend	32	13	0.41
			Weekday	60	17	0.28
		Motunau	Weekend	32	13	0.40
			Weekday	60	2	0.04
					45	
Jan-Apr	Sampling	Kaikōura	Weekend	42	18	0.42
			Weekday	78	21	0.28
		Motunau	Weekend	42	17	0.40
			Weekday	78	3	0.04
					59	
May-Sep	Winter	Kaikōura	Weekend	45	10	0.22
			Weekday	108	15	0.14
		Motunau	Weekend	45	9	0.20
			Weekday	108	2	0.02
					36	
		Annual total			140	

2.4 Expanding the survey to include rock lobster fishers

The expansion to include rock lobster required a dawn start (4 hours extra per day in summer) at Kaikōura but not at Motunau. Lobster effort is treated as a separate stratum to line fishing effort but was collected to the same sampling plan employed for line fishing.

This plan is based on effort targeted at BCO/SPE by line fishers and there was insufficient data available at planning time for lobster fishing on which to base any changes. In 2003 surveying at Kaikōura started at 7:00 a.m. and almost all vessels retrieved earlier than 10:00 a.m. had been lobster potting. Unfortunately, full interviews were not carried out on those non-target trips, so trip start time was not often collected. In 2009 surveying actively avoided lobster fishers by starting at 10:00 a.m.

Advice sought from "The Guardians" is that vessels can depart as early as 5:00 a.m. in summertime to check pots, taking between a half hour and an hour to complete the trip. The 2012–13 survey started at dawn to intercept fishers returning from checking lobster pots (Table 6).

Effort targeted at rock lobster is analysed as a separate stratum to line fishing effort. Where there were mixed target trips, the trip was used in both strata. Catch rates for rock lobster depend on fishing method, and new fields for dive hours, number of tanks, and number of pot lifts were included in the survey questionnaire. Tail width measurements to the nearest 1 mm (rounded down) were obtained using vernier callipers supplied by the Rock Lobster Industry Council, and undamaged lobster were weighed, in tared buckets, to the nearest 1g by electronic balance. The sex and any "old" damage was also recorded for each lobster.

Examination of data collected in previous surveys suggests that interviews were not always completed once vessels were identified as non-line fishing; this makes any comparisons, with respect to rock lobster fishing, with previous studies impractical.

Table 6: Start times and total hours of sampling (including travel time) by month adjusted for sunrise time and daylight saving.

Month	Start	Finish	Total time Minutes	Total time Hours
Oct	6:30	18:00	690	11.5
Nov	6:00	19:00	780	13.0
Dec	6:00	19:00	780	13.0
Jan	6:00	19:00	780	13.0
Feb	6:00	19:00	780	13.0
Mar	7:00	18:00	660	11.0
Apr	7:30	18:00	630	10.5
May	7:30	17:30	600	10.0
Jun	8:00	16:30	510	8.5
Jul	8:00	16:30	510	8.5
Aug	7:00	17:30	630	10.5
Sep	6:30	17:30	660	11.0

2.5 Estimation of daily effort for finfish

A survey design using the bus route method (Pollock et al. 1994) was used to sample the six Kaikōura boat ramps, and schedules were constructed according to Jones & Robson (1991). This sampling method provides logistical efficiency while still allowing the daily schedule to be randomised.

For each Kaikōura survey day, the starting location and direction of travel (north or south) was chosen randomly using an Excel worksheet routine similar to that developed by Sumner et al. (2002). Daily interview schedules for each access point were constructed using data on wait time and travelling time. Wait time is the time spent at a ramp counting boat trailers and interviewing anglers, and travelling time is the time required (by car and/or walking) to travel between each access point. A prototype schedule that maps the interview route in terms of cumulative time (waiting + travel time) is shown in Appendix1.

At Motunau, a simple access point design was utilised for the single boat ramp that launches onto a tidal bar.

Sampling encompassed the entire fishing day. In Kaikōura, sampling ran from 0600 hrs during November to February, and 0700 hrs during March and 0730 hrs in April. The previous survey, done in 2009, started at 10 a.m. to avoid rock lobster fishers who were retrieving pots that had been set overnight. Sampling at the Motunau boat ramp occurred over the high tide each survey day, because the majority of fishing trips are three to four hours in duration with boats getting out over the bar prior to high tide and returning no later than two hours after high tide.

Estimates of total daily effort (vessel hours) for sample day *m* in Kaikōura were based on the duration that trailers were observed parked at each ramp and estimated by the method of Jones & Robson (1991) as follows:

$$e_m = fT\sum_{i}^{n}\left[\left(\frac{1}{w_i}\right)\sum_{j} X_{ij}\right] \qquad (1)$$

where T is the time taken to complete the bus route, (varied depending on weather, but generally between 10 and 13 hours), n is the number of boat ramps (5), w_i is the interviewer wait time at boat ramp i, X_{ij} is the time trailer j spends at boat ramp i during the sample session.

Where $\sum X_{ij}$ is the total effort (vessel-hrs) for a single session (ramp) $_i$ calculated from

$$\sum X_{ij} = \mathrm{TbW_i} - \sum (\mathrm{T_i} - r_j) + \sum (\mathrm{T_i} - L_j) \quad (2)$$

$\mathrm{TbW_i}$ is the number of trailers at the beginning of the session multiplied by the session wait time, $\sum (\mathrm{T_i} - r_j)$ sums the session finish time minus retrieval time for each trailer removed, and $\sum (\mathrm{T_i} - L_j)$ sums the session finish time minus launch time for every vessel launched at boat ramp $_i$ during the sample session.

2.5.1 Correction to number of trailers parked at start of session for off-site parking

Daily effort based on boat ramp parking area trailer counts will be underestimated when a vessel is launched but the trailer is removed off-site. The incidence of off-site parking varies among ramps depending on proximity to residential areas, whether or not the ramp is part of a camping ground (as for Boat Harbour), and the degree of security provided. Retrievals observed using trailers that had been kept off-site were recorded on the session sheet for each ramp, and the proportion was used to adjust upwards the number of parked trailers counted at the start of the session. Off-site launches could have been used to calculate this proportion instead, but we had better observation of boats retrieved than of boats launched.

In 2013, it was not unusual for the number of trailers at the start of session to be zero, in which case the correction could not be applied as a multiplier. In 2013, the correction was made by adding the actual number of 'off-site' retrievals observed, to the start count of trailers, for each individual session.

The number of trailers at the start of the session (Tb) in equation (2) was corrected upwards by the inclusion of the actual number of vessels that were retrieved using off-site trailers.

2.5.2 Correction to daily effort estimates for effort prior to sampling

The proportion of effort that occurred before the sampling start time was established from boat ramp interviews and used to scale up the daily effort estimates. Surveyors stayed at the last ramp until the last trailer was retrieved and no correction was therefore required for effort that occurred after the hours surveyed. Multipliers based on the ratio of effort before survey start time to the rest of the effort were calculated for each area separately and were greater in 2009 than in 2003 or 2013.

The correction factor f (Sumner et al. 2002) was used to adjust the effort for fishing that occurred before sampling commenced for the day at time t:

$$f = \frac{\sum_j \left(r_j - L_j\right)}{\sum_j b_j} \quad (3)$$

where

$$b_j = \begin{cases} r_j - t, & L_j < t \\ r_j - L_j, & L_j \geq t \end{cases}$$

r_j is the retrieval time for boat j and L_j is the launch time for boat j.

2.5.3 Correction to daily effort estimates for relevance to blue cod and sea perch

The proportion of vessels that line fished for blue cod or sea perch was determined for each area from boat ramp interviews and was used to modify the estimates of average daily effort. The number of vessels targeting either blue cod or sea perch was divided by the total number of private vessel retrievals,

rather than successful interviews, to take account of vessels that were launched for purposes other than line fishing (e.g., lobster potting, skiing).

The proportion of vessels that fished for lobster was also used to obtain relevant effort estimates for rock lobster catch rates and total removals. This was done separately for potting and for diving. Some vessels reported multi-method trips and those trips were included in both statistics.

Estimates of total daily effort (vessel hours) were corrected downwards for relevance using multipliers calculated from the proportion of vessels interviewed that had been line fishing, estimated for each area stratum (over the whole year for Kaikōura and Motunau separately).

$$e_m = e_m R \tag{4}$$

where R = number of vessels line fishing for BCO or SPE / number of vessels interviewed.

The fishing effort (vessel hours) for sample day *m* in Motunau was more simply the vessel hours observed, calculated from trailer counts as for a single session (ramp) and subsequently corrected as described for early effort, off-site trailers, and relevance:

$$e_m = Rf \sum X_{ij} \tag{5}$$

2.6 Estimation of total effort for finfish

Although not required for the estimation of harvest, total effort for the three relevant fishing methods (line fishing, lobster potting, and diving) is estimated for this study. Total daily effort in each area/day type stratum was scaled up to the number of days in the stratum to get estimates of total relevant effort in vessel-hours for the period. For clarity, the equations for total effort are given in Appendix 4.

2.7 Estimation of total catch for finfish

Previous methodology estimated total effort for each stratum and multiplied it by the average catch rate per stratum to get total harvest per stratum. Estimation of the variance of those estimates also incorporated the variances of catch and of duration at the level of individual interviews.

In this study, we follow the methodology described by Holdsworth (2014) and estimate total daily harvest by multiplying total daily effort by the average catch rate across all ramps on the sample day. We describe total harvest for each stratum using the mean and variance of the daily estimates. Thus, the estimation of uncertainty is done on data amalgamated to daily resolution, and will be underestimated somewhat, but is comparable to other current surveys currently approved by the Working Group.

The ratio-of-means catch rate for each day ($\widehat{H}m$) is estimated as:

$$\widehat{H}_m = \frac{C_m}{L_m} = \frac{\sum C_{ij}}{\sum L_{ij}} \tag{6}$$

where C_m is the total recorded catch, and L_m the total recorded effort, in vessel-hours, from interviews done on sample day *m*.

and the estimated total harvest for a sample day *m* is:

$$\hat{C}_m = e_m \widehat{H}_m \tag{7}$$

Within each stratum the mean daily harvest $\bar{C}_m$ is:

$$\bar{C}_m = \sum \hat{C}_m / n \tag{8}$$

where n is the number of sampled days, and the associated daily variance is:

$$V(\bar{C}_m) = \sqrt{\Sigma\left(\hat{C}_m - \bar{C}_m\right)^2/(n-1)} \tag{9}$$

The variance of the mean harvest within each stratum is:

$$V\left(\hat{C}_k\right) = (V(\bar{C}_m)/\sqrt{n}\,) * \sqrt{(1-n)/\mathrm{N}} \tag{10}$$

where N is the total number of fishing days in the stratum, and 1 – n/N is the finite population correction that takes into account the fraction of the fishing days that are sampled (Manly 2009, section 2.3).

It follows that the estimated total harvest in the whole stratum is:

$$\mathrm{C_k} = \mathrm{N}\ \bar{C}_m \tag{11}$$

with associated variance

$$V(C_k) = N\ V(\hat{C}_k) \tag{12}$$

The total harvest (for area, and overall) was estimated by summing the catch for each stratum as follows:

$$\hat{C} = \sum_{k=1}^{n} \hat{C}_k \tag{13}$$

The variance of $\hat{C}$ is estimated as:

$$V\left(\hat{C}\right) = \Sigma_{k-1}^{n} V\left(\hat{C}_k\right)^2 \tag{14}$$

The standard error of $\hat{C}$ is estimated by the usual method:

$$SE(\hat{C}) = \sqrt{V(\hat{C})} \tag{15}$$

Harvest estimates in number of fish are converted to total harvest weight by multiplying by mean weight estimates.

2.8 Estimation of total catch of rock lobster

The estimates of total harvest of rock lobster are obtained using a similar approach, except that catch per trip was used for CPUE without any regard to trip duration, number of pot lifts, or number of divers. Daily effort was simply an expansion of the number of relevant interviews obtained per minute of wait time to the length of the day (in minutes) for each ramp summed across the Kaikōura bus route, or the actual number of relevant interviews obtained at Motunau. Catch rates in each area for each day were calculated across ramps from relevant interviews as number of lobster / number of trips recorded. Daily harvest was estimated by multiplying daily effort by daily catch rate.

At ramp *i* on day *m* in a stratum the total number of boat trips observed *e* per minute of wait time *w* is e_{im}/w_{im}. The estimated total number of trips for the whole of fishing day *m* at that ramp is therefore the length of the fishing day T (in minutes) times the trips per minute $T_m\ e_{im}/w_{im}$ and the estimated total number of trips for all ramps for each bus route on day m is E*m*

$$E_m = T_m \sum_i (e_{im}/w_{im}) \tag{5}$$

To estimate the total harvest on day *m* it can be noted that for all ramps combined the mean harvest per trip is $\sum C_{im}/\sum e_{im}$ on that day, where the summations are over the *i* ramps. This then provides an estimate of the total harvest for each bus route on day *m* by multiplying by the expanded total number of trips on day *m*, i.e.,

$$C_m = E_m \sum C_{im}/\sum e_{im} \quad (6)$$

Harvest per stratum and total harvest were estimated with associated variance using the same equations 7 to 15 as are described above.

The equations are based on those described by Holdsworth (2014), but in reality were much simpler because we have only one bus route, and one all-day ramp. We also did not scale up effort by the number of vessels that were missed or with skippers that refused to be interviewed as: a) the numbers were very small (less than 4%) and b) we could not assume that missed vessels were fishing for rock lobster.

For rock lobster separate length weight regressions for male and female fish were used to estimate the weight of each measured lobster; these were summed and divided by the number of measured fish to get the mean weight in each stratum and this was done for the two fishing methods (potting and diving) separately.

2.9 Catch rates and fish lengths

Anglers were asked to participate in a two minute prepared questionnaire to identify the target species and to differentiate between fish caught and kept (including for bait), and fish caught and released.

The observations of catch per trip collected from interviews describe the total catch per species, and in the case of blue cod, the legal catch. Because fish of any size can be returned to the water, both these estimates require the fisher to recall the number of fish that were released. Catch rates can only be monitored accurately at sea, but in boat ramp surveys they rely on fisher recall and are therefore subject to bias. They are collected to describe the experience of the fisher and are distinct from harvest rates, which can be verified at the boat ramp and which reflect the removals from the population.

The estimates of total catch were based on harvest rates (fish retained) and therefore represent actual removals.

Fork length (F.L.) measurements were taken of all blue cod and sea perch landed from a trip when time allowed, and a sample (minimum of five fish) when interviewers were very busy. Catch and harvest rates for blue cod and sea perch were calculated from those fishing trips that targeted either of the species by line fishing.

2.10 Charter vessel logbooks

A charter vessel logbook designed for this project was distributed to vessel operators in 2003 and 2009 with variable success. They were superseded in 2013 by a mandatory MPI Amateur Charter Vessel Activity Catch Return (ACV-ACR).

In 2013, observers placed on 30 commercial charter vessels filled out logbooks and measured fish. Fish lengths and proportion of the released catch that was legal size are therefore available only for trips that carry observers.

2.11 Other sources of information

MPI charter Activity Returns were analysed to describe total effort and total catch of the target species by the charter fleet. They record total catch and retained catch in numbers for each species, but do not

record the proportion of fish released that were of legal size. Operators voluntarily included sea perch catches in addition to the required blue cod and lobster. They also estimated the weight of the harvest for the three species of interest.

Recreational catches on commercial vessels under section S111 are described.

3. RESULTS

3.1 Boat ramp survey: sampling achieved

Sampling began in October 2012 and achieved coverage of 79% of weekends and 32% of weekdays in the three month period October to December. During the four month period that is comparable with previous surveys (January to April), 83% of weekends and 31% of weekdays were sampled, and in the five months from May to September, 42% of weekend days and 16 % of weekdays were sampled (Table 7). The number of valid days sampled included days of bad weather when no fishing was observed.

Table 7: Coverage of temporal strata (weekdays and weekend days between 1 October 2012 and 30 September 2013); number of days in strata, number of days sampled, and percent coverage.

Period	Strata	Days in strata	Days sampled	% coverage
Oct-Dec	Weekday	59	19	32
	Weekend	33	26	79
Jan-Apr	Weekday	78	24	31
	Weekend	42	35	83
May-Sep	Weekday	108	17	16
	Weekend	45	19	42

An attempt was made to approach all vessels; however, a few in each year were missed (coded 'N') when interviewers were particularly busy (4% in 2013), and a few skippers refused to be interviewed (coded 'R': 5% in 2013). Full interviews were coded 'I' and were achieved for 90% (in 2003), 74.6% (in 2009), and 72% (in 2013) of the vessel retrievals (Table 8). The difference is explained by the increase in the number of vessels launched for other than recreational fishing (coded 'O') (from 3.2% in 2003 to 16.9% in 2009) and an increase in vessels identified as charter vessels (coded 'X') (from 2.7% in 2009 to more than 4% in 2013).

The total number of full interviews done in 2012–13 was 1931 (Table 8), of which 1372 were obtained during the January to April period. When the dataset was trimmed to days valid for catch rate and total effort estimates, the number of relevant "I" coded interviews that reported line fishing for blue cod or sea perch during January to April was 338 in Kaikōura and 250 in Motunau (Table 9), very close to the target of 300 in each area.

In Kaikōura, the majority of trips were targeting rock lobster, and surveyors obtained 469 interviews relevant to potting activity during January to April, compared with 70 at Motunau (Table 10). Multi-method trips were common, and, in those instances, the same vessel-trip is included in the statistics for each method. The intercept rates (number of relevant interviews per hour) achieved in 2013 at Kaikōura are also given for each boat ramp to inform the design for the next survey.

Table 8: Comparison of interview outcomes for the 2003, 2009, and 2012–13 surveys; all days and boat ramps included. An interview was initiated for each observed boat retrieval, but only "I" interviews yielded catch rate estimates or fish lengths. "O" outcome includes commercial or charter vessels counted in the first few days of the survey but not counted thereafter.

Interview		2003		2009		2013	
outcome	Description of vessel retrieval	Number	%	Number	%	Number	%
I	**Interview**	**673**	**90.0**	**754**	**74.6**	**1 931**	**72**
O	Other (Boats used for skiing etc.)	24	3.2	171	16.9	380	14
N	Not interviewed (Missed)	41	5.5	31	3.1	99	4
R	Refused to be interviewed	1	0.1	27	2.7	129	5
X	Charter boat operators (not	4	0.5	27	2.7		
Z	Other	5	0.7	3	0.1	19	0.6
	Total Initiated	748		1 013		2 666	

Table 9: Valid harvest rate estimates relevant to line fishing obtained from boat ramp interviews for the whole survey period 01 October 2012–30 September 2013. Interviews are total private boat retrievals observed (not just "I" interviews); BCO/SPE interviews are the numbers of boats that had been line fishing and targeted blue cod or sea perch. The ratio f was applied to trailer counts to apportion relevance to daily effort estimates.

Location	Period	Days sampled	Interviews (retrievals)	BCO/SPE interviews	BCO/SPE ratio	2012–13 Intercept rate BCO/SPE interviews/day
Kaikōura	Oct-Dec	30	615	179	0.29	6.0
	Jan-Apr	39	916	338	0.37	8.7
	May-Sep	25	141	49	0.35	2.0
Motunau	Oct-Dec	15	342	168	0.49	11.2
	Jan-Apr	20	456	250	0.55	12.5
	May-Sep	11	66	43	0.65	3.9

Table 10: Valid harvest rate estimates relevant to lobster fishing (either by potting or diving) obtained from boat ramp interviews for the whole survey period 01 October 2012–30 September 2013. Interviews are total private boat retrievals observed (not just "I" interviews), CRA (method) interviews are the numbers of boats that had been targeting rock lobster by method. The ratio f was applied to trailer counts to apportion relevance to daily effort estimates.

Location	Period	Days sampled	Interviews (retrievals)	CRA interviews	CRA interviews	CRA ratio	CRA ratio	2012–13 interviews/day
Kaikōura	Oct-Dec	30	615	388	21	0.63	0.03	13.6
	Jan-Apr	39	916	469	50	0.51	0.05	13.3
	May-Sep	25	141	73	4	0.52	0.03	3.1
Motunau	Oct-Dec	15	342	61	95	0.18	0.28	10.4
	Jan-Apr	20	456	70	121	0.15	0.27	9.6
	May-Sep	11	66	14	9	0.21	0.14	2.1

The number of measurements of blue cod and sea perch (131 and 124 respectively) obtained from the January to April period was less, in each area, than the 150 of each species recommended by Hart & Walker (2004) as necessary to detect a 1-cm change in mean size. The increased pressure at ramps (on fishers, not surveyors) combined with Fishery officers also measuring fish at Motunau, are reasons given for this shortfall.

In contrast, the number of lobsters measured at Kaikōura was 146 (greater than the number of sea perch measured), and at Motunau was almost 44, which was almost half as many as the blue cod measured (Table 11). Surveyors described lobster fishers as regulars, with more time to talk and smaller total catches than line fishers.

Once the questionnaire was completed, we would ask 'Do you have time for us to measure your fish?' It really was a time restriction that was decided by each fisher and more often than not they would decline. There were a few reasons why the required measurements couldn't be obtained:

1. Many fishers fillet at sea and there is nothing to measure. Particularly with SPE which was often used as bait in cray pots.

2. The boat ramps are very busy. The number of samplers was adequate, but there was not enough physical room at the boat ramp to undergo measuring. Sometimes we pushed it to get the measurements, but this caused drama at the ramps.

3. Surveyors measured the total catch of a species. If we measured part catches then fishers were inclined to just give us the big ones to measure. We negated this by making sure that we measured the total catch. If it was a large catch once again time was a factor.

4. There was also a challenge at Motunau because MPI officers were present during the peak period on most survey days. They were checking and measuring fish. We were unable to do our survey or measure until after the MPI officers, and often fishers would decline after this.

Table 11: Number of measurements obtained for the whole period (% of reported catch) for 01 October 2012–30 September 2013 and number of rock lobster that were also weighed.

		Measured			TW-Wgt
Location	Period	BCO	SPE	CRA	CRA
Kaikōura	Oct-Dec	36 (13)	235 (15)	334 (13)	178
	Jan-Apr	32 (4)	116 (4)	146 (6)	59
	May-Sep	10 (12)	23 (5)	60 (26)	24
Motunau	Oct-Dec	160 (8)	12 (4)	106 (7)	22
	Jan-Apr	99 (4)	8 (2)	44 (2)	8
	May-Sep	39 (11)	23 (32)	3 (3)	0

3.2 Charter vessels: sampling achieved

Logbooks were filled out by observers for 30 charter vessels trips in 2013. Observers also measured almost all retained fish and recorded the numbers of legal and sub-legal releases (Table 12).

Data from MPI Charter Activity Returns were summarised for trips where the port of departure was some recognisable variant of Kaikōura or Motunau (free text field). The forms recorded the total number of fish caught, and the number retained, with no indication of the proportion that were of legal size (Table 13). Many operators completed less than 5 trips in the year, with the main operators completing up to four trips per day.

Table 12: Description of charter vessel logbook data for Jan to April 2013: number of charter vessel operators, trips, fishers, and the number of measurements obtained for blue cod and sea perch (% of retained catch).

Location	Operators	Trips	Fishers	BCO measured	SPE measured
Kaikōura	7	27	120	136 (86)	655 (80)
Motunau	1	3	29	172 (100)	209(100)
Total	8	30	149	308	864

Table 13: Charter activity reported on MPI ACV-ACR forms for the fishing year 2012–13 from Kaikōura or Motunau. Data given are number of trips, number of operators, and total number of blue cod, sea perch, and lobster retained.

			Total harvest (number retained)		
	Operators	Trips	BCO	SPE	CRA
Kaikōura	16	997	5 668	21 031	5 817
Motunau	5	109	7 849	2751	872

3.3 Descriptive analysis

3.3.1 Private vessel recreational fishing

In 2013, about 80% of private vessel fishers interviewed were male, and the proportion of female participants was slightly greater at Kaikōura than at Motunau (Table 14). This is almost the same as was observed in 2009 and 2003. About half the fishers in 2009 were aged 31 to 50 and almost another 20% were in the age bracket 50 to 60 years (Table 15). Only about 6% of anglers were over 60 years. In 2013 there was a shift towards older participants with 14% over 60 years.

Line fishing trips tended to be targeted at blue cod, potting trips were targeted at rock lobster, and diving trips at rock lobster or pāua. It was common for more than one method to be used on a trip. Most trips from Motunau were line fishing trips (55%), with dive trips accounting for much of the remainder (27%). This is a high proportion of diving compared with Kaikōura (8%) where there is more shore access to dive sites. Potting was a more common method on vessels operating from Kaikōura (52%) than from Motunau (16%); line fishing accounted for 31% of Kaikōura trips (Table 16).

Line fishing trips that targeted blue cod or sea perch generally carried an average of about three fishers with slightly fewer lines than fishers and stayed on the water for about three and a half hours (including travel time). There is some suggestion of small increases in those statistics between 2003 and 2009 (Table 17) that might be consistent with larger and more comfortable boats, although no data on vessel size are included.

The catches were dominated by sea perch and lobster in Kaikōura, followed by blue cod. This contrasted with Motunau where blue cod was the main catch, followed by rock lobster and sea perch. Other species among the top ten in both areas included dogfish, barracouta, red cod, pāua, and kina. Butterfish was an important part of the catch at Kaikōura, but not at Motunau, and blue moki was more commonly included in catches at Motunau than at Kaikōura (Table 18).

Table 14: Distribution of sex of recreational anglers on private vessels by area in January-April 2013.

2013	%	
Location	Male	Female
Kaikōura	78	22
Motunau	83	17
Overall	79	21

Table 15: Distribution of age of recreational anglers on private vessels by area in January-April 2013.

2013	Number in each age group							Total
	<15	15–20	21–30	31–40	41–50	5160	61+	number
Kaikōura	188	86	198	284	415	463	307	1 941
Motunau	84	39	96	184	265	210	101	979
Overall	272	125	294	468	680	673	408	2 920

Table 16: Percentage of private vessel trips in each area (from successful interviews, January to April) that used the main fishing methods (diving, lining, and potting), targeted at the target species (blue cod, sea perch, and lobster). Other includes trips where no target species was specified. Some trips fished more than one method and these trips are double-counted. Percentages sum to 100 in each area.

	% of trips by fishing method			
Target species	Dive	Line	Pot	Other
Kaikōura (916 trips)				
Blue cod	0	31	0	0
Sea perch	0	5	0	0
Rock lobster	5	0	52	0
Other	3	3	0	0
Motunau (456 trips)				
Blue cod	0	55	0	0
Sea Perch	0	0	0	0
Rock lobster	27	0	15	0
Other	1	1	1	0

Table 17: Average effort on trips by private vessels targeting blue cod or sea perch in the period January to April in 2003, 2009, and 2013.

Private vessels	Survey year	Mean number fishers per trip	Mean number hours per trip	Mean number lines per trip
Kaikōura	2003	2.87	3.15	2.27
	2009	3.01	3.22	2.57
	2013	2.73	3.25	2.38
Motunau	2003	3.35	3.21	2.43
	2009	3.34	3.41	2.86
	2013	3.14	3.39	2.81

Table 18: Total catch (numbers of fish caught), and % retained, of the top 10 species by area from interviews of private vessel fishing in 2013.

		2009		2013	
Location	Species	Total catch	% of catch retained	Total catch	% of catch retained
Kaikōura	Sea perch	5 545	64	5 518	58
	Rock lobster	1 744	59	5 015	50
	Blue cod	1 304	66	1 551	50
	Spiny dogfish	315	24	204	2
	Butterfish	314	95	213	99
	Barracouta	86	66	159	55
	Red cod	80	94	148	65
	Pāua	56	88	221	98
	Parore	38	95	0	–
	Kina	28	54	25	100
Motunau	Blue cod	5 657	51	5 056	53
	Rock lobster	1 464	84	2 349	82
	Sea perch	914	51	768	44
	Spiny dogfish	108	6	105	1
	Pāua	63	68	218	97
	Red cod	19	74	37	59
	Barracouta	15	53	44	52
	Blue moki	15	100	57	98
	Kina	12	100	25	100
	Wrasse spp.	11	82	151	29

3.3.2 Marlborough Sounds question

There was no evidence of refugee fishers from Marlborough adding to the fishing pressure in the survey area. During full interviews, surveyors asked the following question:

"You may be aware that the Blue Cod fishery in the Marlborough Sounds is closed to recreational fishing. Was your trip today:

A. One that would be here to [Kaikōura/Motunau] regardless of that,
B. One that would have been to Marlborough Sounds, if the blue cod fishery were open,
C. Would have gone to some other fishery today, but not Marlborough Sounds, e.g., due to weather or road closures,
D. Would have gone to Marlborough Sounds despite blue cod closure but road conditions, boat, passengers, weather or other conditions prevented it"

Of the fishers, 1905 confirmed option A, 18 responded with option B, and 4 with option D.

3.3.3 Charter vessel fishing

Charter boats carried on average between 4 and 5 customers per trip at Kaikōura and closer to ten customers per trip from Motunau in 2013 (Table 19). Differences from 2009 likely indicate the inconsistencies from year to year in the participation of charter vessels and a high turnover of operators that has been commented on in previous reports. With only 30 charter trips represented for 2013 comparisons cannot be made with previous years, or with private vessels, and activity will be monitored into the future on the basis of data provided on the MPI Amateur Charter Vessel Activity Catch Return (ACV-ACR) form. The observed trips did, however, provide good coverage of fish measurements for charter fishing that are not otherwise obtainable. Species composition at Kakoura and Motunau broadly

reflects that caught on private vessels and confirms the prevalence of sea perch and lobster at Kaikōura, in contrast to blue cod being the most important component of the catch at Motunau (Table 20).

Table 19: Average effort in trips by charter vessels from logbooks, January to April (includes some December 2008 days).

Charter vessels	Survey year	Mean number fishers per trip	Mean number hours per trip	Mean number lines per trip
Kaikōura	2003	8.60	3.77	5.74
	2009	6.83	3.63	6.87
	2013	4.44	3.26	3.39
Motunau	2003	8.68	6.45	8.94
	2009	10.07	5.78	10.07
	2013	9.67	7.50	7.17

Table 20: Total catch (numbers of fish caught), and % retained, for all species reported in charter vessel logbooks in 2013 by area.

Location	Species	Total number caught	% of catch retained
Kaikōura	SPE Sea perch	1 208	68
	CRA Rock lobster	886	20
	BCO Blue cod	174	91
	SPD Spiny dogfish	29	0
	RCO Red cod	23	87
	WSE Wrasse	13	85
	CAR Carpet shark	8	0
	BAR Barracouta	5	100
	RRC Red scorpion fish	5	0
	OCT Octopus	3	33
	TAR Tarakihi	3	100
	BCD Black cod	1	100
	EEL Eel	1	0
	HAP Hāpuku	1	100
Motunau	BCO Blue cod	446	39
	SPE Sea perch	219	95
	CRA Rock lobster	73	49
	HAP Hāpuku	47	100
	WSE Wrasse	13	0
	TAR Tarakihi	9	67
	BAR Barracouta	7	100
	SCH School shark	6	67
	SPD Spiny dogfish	6	0
	EEL Eel	2	0
	KAH Kahawai	1	100
	OCT Octopus	1	100
	SNA Snapper	1	100
	WAR Blue warehou	1	100

3.4 Daily effort (private recreational vessels)

Estimates of total daily effort on sampling days were based on the duration that trailers spent parked at each ramp and were adjusted for effort missed because trips began before sampling did, for trailers parked elsewhere and not included in the census, and for the proportion of vessels that were launched for other purposes (potting or diving for rock lobsters for example).

Even before these adjustments were made it was evident that the average daily effort had increased in each stratum, except Motunau weekends, between 2009 and 2013. A positive adjustment for trailers kept off-site is needed given the observed overflow from full boat ramp parking areas.

3.4.1 Correction for off-site parking

In 2013, perhaps because of the earlier start time, combined with the increased traffic at ramps, the number of trailers counted at the start of the session, particularly at the Public Ramp was often zero, and the correction could not effectively be applied as a multiplier. The number of vessels that were observed retrieved on off-site trailers was therefore added to the number of trailers counted at the start of each session. This was done for every individual session and the resultant ratio calculated from the adjustment. This correction was greatest for the Public Ramp at Kaikōura (2.94), indicating that 2 out of every three vessels launched at this ramp were not evidenced by parked trailers. A smaller increase in the number of off-site trailers at Boat Harbour was also recorded, but there was little or no change at other ramps including Motunau (1.03) (Table 21).

Table 21: The proportion of trailers kept off-site as observed during vessel retrievals in January to April in 2009 and 2013. The multiplier applied to the trailer counts at start of a session by boat ramp. In 2003 there was only one instance recorded of a trailer kept off-site, and this correction was not deemed necessary.

Boat ramp	Proportion of trailers kept off-site		Correction to number of trailers at start of session	
	2009	2013	2009	2013
Armers Beach	0.09	0.00	1.09	1.00
Boat Club	0.08	0.08	1.08	1.08
Boat Harbour	0.13	0.28	1.13	1.28
Barney's Rock	0.00	0.00	1.00	1.00
Motunau	0.02	0.03	1.02	1.03
Public Ramp	0.37	1.94	1.37	2.94
Pier Slipway	0.00	–	1.00	–

3.4.2 Correction for effort prior to sampling

In 2013, survey start times were around dawn (0600 hrs in January and February, 0700 in March, and 0730 in April), and a smaller proportion of trips started before sampling than in 2009 when sampling began each day at 1000 hours. Thus the smaller correction used for Kaikōura in 2013 was closer to that used in 2003 when sampling started at 0700 hours (Table 22). Less understandable is the increase in the required adjustment for early effort at Motunau, but it may be related to the shift in emphasis away from line fishing towards more lobster fishing.

The distribution of start times (obtained from interviews) shows similarly early start times for both potting and line fishing trips, with a second peak in the late afternoon for lobster potting, but confirms that most trips finishing at Kaikōura boat ramps before 1000 hours are returning from lifting lobster pots; whereas most line fishing trips return later, and the 1000 hours start of sampling that was used in 2009 would likely have missed few returning line fishing trips (Figure 1).

Table 22: Comparison of the corrections used in the two surveys to adjust daily effort for effort prior to the start of sampling.

Location	Survey year	Proportion of trips that started before sampling began	Correction for boats launched early
Kaikōura	2003	0.016	1.016
	2009	0.139	1.139
	2013	0.025	1.025
Motunau	2003	0.410	1.410
	2009	0.036	1.036
	2013	0.360	1.360

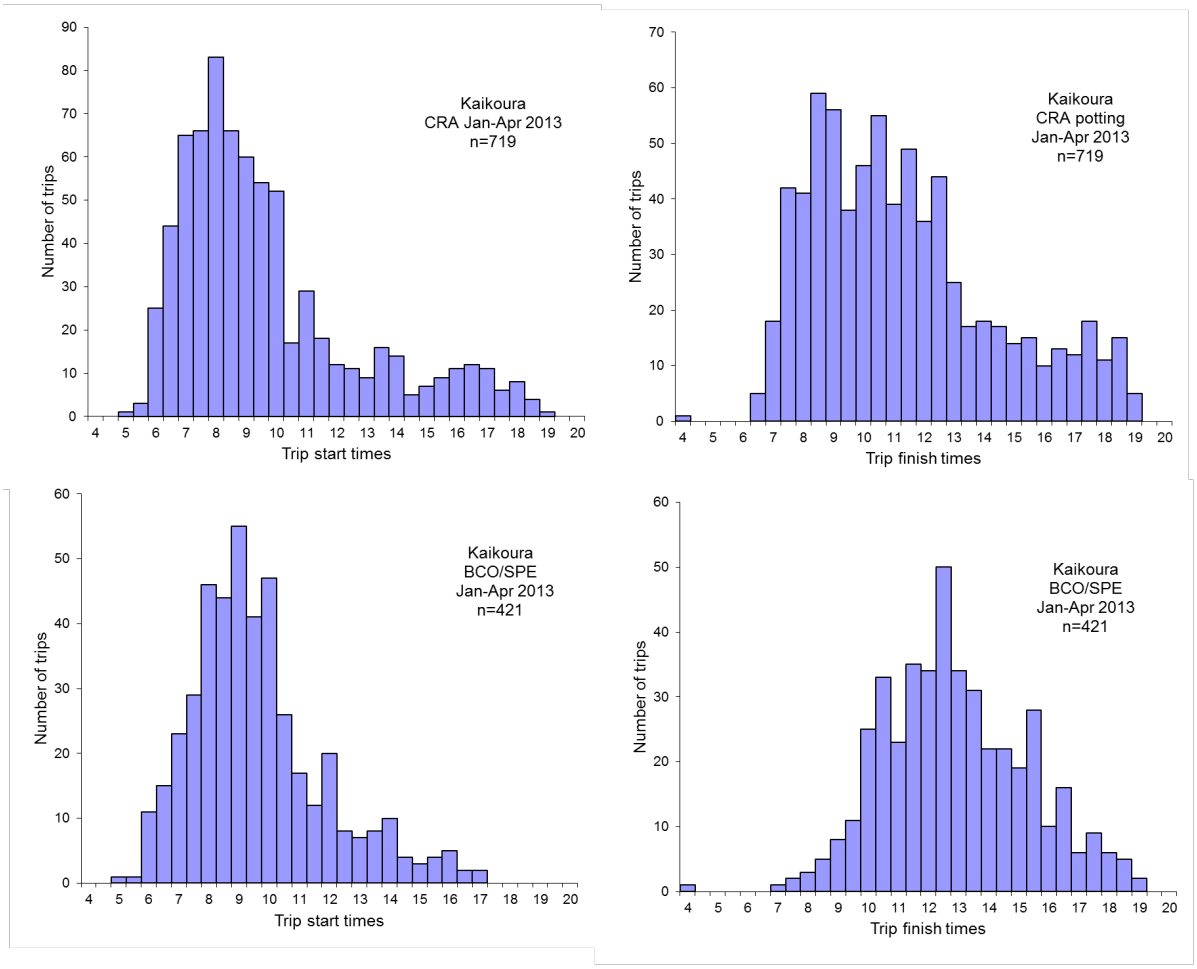

Figure 1: The distribution of trip start and finish times at Kaikōura boat ramps for lobster potting compared with those for line fishing, established from interviews for January to April in 2013. Start times at Motunau were determined by the tide.

3.4.3 Daily effort relevant to fishing for blue cod or sea perch

The proportion of vessels that targeted blue cod or sea perch was about 37% at Kaikōura ramps and just under 55% at Motunau (Table 23). This was a change downward from the 2009 survey in Kaikōura and was understandable given the improved coverage of rock lobster vessels obtained with an earlier start time, but there was an even greater decline for Motunau.

Table 23: Proportion of vessels that line fished for blue cod or sea perch in 2003, 2009, and 2013 as ascertained from interviews (includes some multi-method trips), but expressed as a proportion of total vessel retrievals (January-April). Other vessels included vessels that fished for lobster, were launched for skiing, and charter fishing vessels.

Survey year	Proportion of vessels targeting BCO/SPE	
	Kaikōura	Motunau
2003	0.392	0.788
2009	0.397	0.806
2013	0.369	0.548

3.4.4 Total line fishing effort

Effort targeted at blue cod or sea perch during the January to April period in 2013 is estimated to have increased by 58% overall, from 8684 (SE 1459) vessel-hours in 2009 to 13 558 (SE 1446) in 2013. Most of the increase occurred in Kaikōura with that area accounting for 79% of the total relevant effort in 2013 compared with 74% in 2009 (Figure 2, Table 24). The greatest increase was an almost threefold increase in effort expended during weekends in Kaikōura (Table 24).

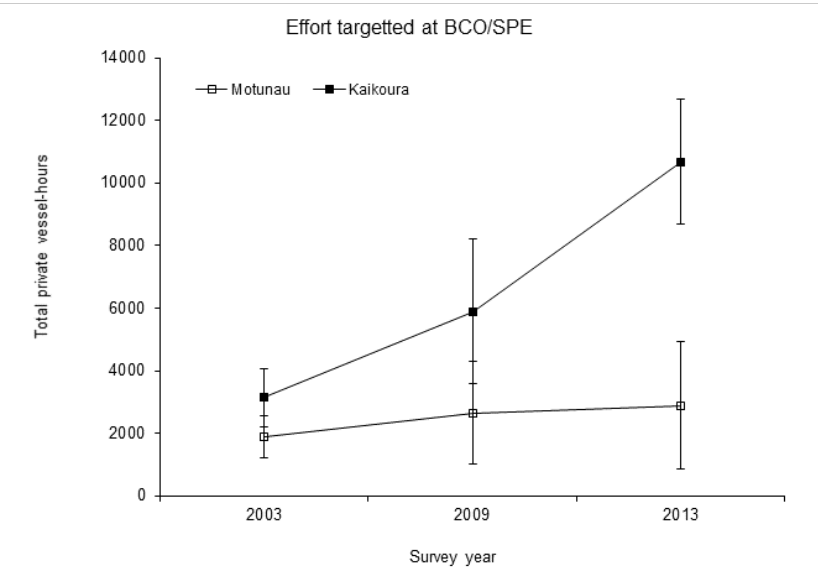

Figure 2: Comparison of total relevant effort (vessel-hours ± 2 SE) by area for January to April in 2003, 2009, and 2013.

Table 24: Comparison of total relevant effort (estimated vessel-hours) by stratum for January to April in 2003, 2009, and 2013 and the percentage of total BCO/SPE effort (vessel-hours) by area and by day type within area for each survey year.

Survey year	Area	Day type	BCO/SPE effort vessel-hours (SE)	% of BCO/SPE fishing effort by area	% of BCO/SPE Fishing effort by area/day type
2003	Kaikōura	Weekend	1 931 (280)		62
		Weekday	1 201 (371)	62	38
	Motunau	Weekend	1 618 (320)		86
		Weekday	695 (90)	38	14
2009	Kaikōura	Weekend	2 889 (558)		45
		Weekday	3 536 (1 150)	74	55
	Motunau	Weekend	1 915 (617)		85
		Weekday	344 (339)	26	15
2013	Kaikōura	Weekend	6 863 (881)		64
		Weekday	3 815 (503)	79	36
	Motunau	Weekend	1 547 (303)		54
		Weekday	1 333 (339)	21	46

3.4.5 Daily effort relevant to fishing for rock lobster in 2013

The majority (67%) of private vessels launching at Kaikōura boat ramps were fishing for lobster, and most of them (51%) were using pots. By contrast, lobster fishing accounted for just over 30% of vessels launched at Motunau, and most (26%).of them were dive boats (Table 25).

Estimates of total effort relevant to rock lobster are given for each stratum in Table 26 and in Table 27 for diving to help inform the design of future surveys. The use of vessel-hours is perhaps spurious and was not used in calculations of catch rate or total harvest, but vessel-hours are probably adequate for describing the distribution of effort across season, location, and day type.

Greater than 95% of potting effort is done from Kaikōura boat ramps (Table 26), but dive effort is split more evenly between Kaikōura and Motunau (Table 27).

Table 25: Proportion of vessels that fished for rock lobster in 2013 as ascertained from interviews (includes some multi-method trips), but expressed as a proportion of total vessel retrievals (January-April). The balance of vessels predominantly line fished for BCO/SPE.

	Proportion of vessels targeting CRA	
Method	Kaikōura	Motunau
Potting	0.512	0.055
Diving	0.154	0.260

Table 26: Comparison of total relevant effort (estimated vessel-hours) for CRA potting by stratum for 2013, the percentage of total CRA effort (vessel-hours) by area and by day type within area for each period.

Survey period	Area	Day type	CRA potting effort vessel-hours (SE)	% of CRA potting effort by area	% of CRA potting effort within area by day type
Oct-Dec	Kaikōura	Weekend	5 575 (864)		59
		Weekday	3 940 (788)	97	41
	Motunau	Weekend	264 (61)		100
		Weekday	0 (0)	3	0
Jan-Apr	Kaikōura	Weekend	11 277 (1 448)		64
		Weekday	6 269 (827)	95	36
	Motunau	Weekend	471 (92)		54
		Weekday	405 (299)	5	46
May-Sep	Kaikōura	Weekend	2 559 (12)		46
		Weekday	2 982 (5)	95	54
	Motunau	Weekend	106 (1)		39
		Weekday	168 (0)	5	61

Table 27: Comparison of total relevant effort (estimated vessel-hours) for CRA diving by stratum for 2013 and the percentage of total CRA effort (vessel-hours) by area and by day type within area for each period.

Survey period	Area	Day type	CRA diving effort vessel-hours (SE)	% of CRA diving effort by area	% of CRA diving effort by area/day type
Oct-Dec	Kaikōura	Weekend	466 (70)		59
		Weekday	318 (64)	64	41
	Motunau	Weekend	434 (100)		100
		Weekday	1 (1)	36	0
Jan-Apr	Kaikōura	Weekend	909 (117)		64
		Weekday	506 (67)	50	36
	Motunau	Weekend	775 (151)		54
		Weekday	667 (493)	50	46
May-Sep	Kaikōura	Weekend	206 (1)		46
		Weekday	240 (0)	50	54
	Motunau	Weekend	175 (1)		39
		Weekday	277 (19)	50	61

3.5 Catch rates

The observations of catch per trip collected from interviews are described alternatively as total catch per species and, in the case of blue cod, of legal catch. Because fish of any size can be returned to the water, the estimates of legal catch rate can include both fish retained and fish released and are therefore partly based on fisher recall rather than on verified harvest. These are encounter rates and describe the experience of the fisher, and perhaps the health of the fishery, as distinct from harvest rates, which reflect the removals from the population. Harvest rates were used to calculate total catch.

Trip duration used as the measure of effort in CPUE estimates is similarly obtained from interviews and therefore based on fisher recall.

3.5.1 Blue cod

The observations of catch per trip collected from interviews are compared between seasons for each stratum (Table 28) and between years (Table 29) where they are described alternatively as mean total catch per trip of blue cod, and the mean catch of legal size blue cod caught (regardless of whether kept or released). The standard deviation of the mean legal catch per trip is greater than, or similar to, the mean in most strata and the high variance of catches understandably compromises any analysis of catch rates and catches. Catch per unit of effort (CPUE) is described by the ratio of means (average catch per trip divided by average trip duration) for legal fish caught, and the distributions of those values in each stratum are plotted in Figure 3. The distributions are highly skewed with the long right hand tails that are typical of catch rate data, but show distinctive differences between areas, with little difference between survey years within strata.

The information for charter fishing available from the MPI ACV-ACR forms is summarised in Table 30, but it is not directly comparable, because it does not enumerate the catch of legal size fish.

Catch rates of blue cod are greater at Motunau than at Kaikōura and are also considerably greater for charter vessels than for private vessels, which is not surprising given the greater number of fishers aboard these larger vessels. The differential in catch rates between areas for charter vessels is biased by the larger number of customers carried on the vessels operating from Motunau (see Table 19).

Catch rates of legal size blue cod from private vessels were distributed similarly between years at Kaikōura, averaging less than one per vessel-hour, but generally less than 2 fish per hour, and reported as zero in about 70% of trips (Figure 3). At Motunau, catch rates were distributed more widely, generally reported to be between 1 and 5 fish per hour but not uncommonly up to 10 per hour, with less than 30% of trips reporting a zero catch.

Analysis of the differences between pairs of years was done in log space using quasi-poisson one-way GLMs with a log link function and describes the apparent declines in the catch rate of legal size blue cod between 2009 and 2013 as statistically significant at Motunau, but not at Kaikōura (Table 29).

Table 28: Comparison between areas and survey period of the mean number of blue cod caught per vessel-trip (total and legal) by private recreational vessels targeting blue cod or sea perch by lining in 2012–13. SD is the standard deviation of the observed catch of legal blue cod per trip; harvest rate estimate is the number of sea perch retained per vessel-hour (ratio of means).

		Number of BCO caught per trip			Harvest rate
Location	Period	Total	Legal	SD	
Kaikōura	Oct-Dec	2.6	1.6	3.2	0.525
	Jan-Apr	4.5	2.4	4.5	0.698
	May-Sep	2.8	1.8	3.6	0.553
Motunau	Oct- Dec	23.2		13.4	3.521
	Jan-Apr	19.8	11.5	11.9	3.063
	May-Sep	15.5	8.6	9.2	2.867

Table 29: Comparison between years and between areas of the mean number of fish caught per vessel-trip (total and legal) by private recreational vessels targeting blue cod or sea perch between January and April. Std. dev. is the standard deviation of the catch of legal blue cod per trip, catch rate estimate is number of legal blue cod per vessel hour (ratio of means). Results of one-way quasi-poisson GLM models between years with log-link, p is Pr(>t), significance of difference between years * =0.001 (n.s. is not significant).**

Blue cod			Number of fish per vessel-trip			Number of fish per vessel-hour		
Private		Survey year	All fish caught	Legal fish	Std. dev.	Legal fish	p	Signif.
	Kaikōura	2003	4.80	2.90	5.13	0.92		
		2009	3.88	2.80	5.68	0.87	0.46	n.s
		2013	4.51	2.38	4.46	0.73	0.16	n.s.
	Motunau	2003	22.57	9.87	9.69	3.12		
		2009	25.22	14.44	12.78	4.24	<0.001	***
		2013	19.75	11.54	11.91	3.40	0.003	**

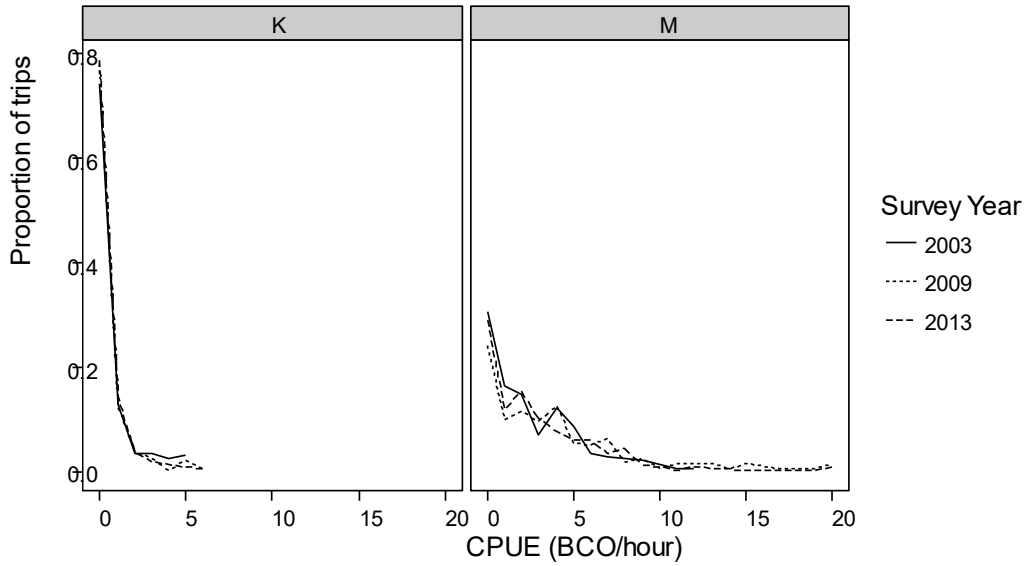

Figure 3: Distribution of catch rates (number of legal blue cod per vessel-hour) from boat ramp surveys of the private vessel fleet at Kaikōura [left] and at Motunau [right] in 2003, 2009, and 2013.

Table 30: Catch rates of blue cod on (positive) trips by charter vessels from MPI Charter vessels activity returns in 2012-13. Number of trips that reported a catch of blue cod, average number of blue cod caught per trip, average number of blue cod retained per trip, and standard deviation of BCO harvest per trip.

		Number of BCO caught per trip		
Blue cod	Number of trips	Total	Retained	SD
Kaikōura	553	12.5	10.25	21.1
Motunau	102	170.9	77.71	29.2

Sub-legal size fish made up a higher proportion of the private vessel catch of blue cod in 2013 than in 2009 in Kaikōura (Table 31), and the accompanying increase in total catch rate supports the possibility that this indicates increased recruitment. At Motunau, however, there was a slight decrease in the total catch of blue cod per trip reported in 2013, as well as in the component of the catch was that was legal size (Table 31).

In 2013, as in 2009, fishers in private vessels reported releasing considerably more blue cod than they were legally required to do. This contrasts with their behaviour in 2003 when most of the legal catch was retained (Table 31).

Table 29: Proportion of catch of blue cod reported as below the MLS of 30 cm, and the proportion of the total catch that was released for fleet, area, and survey year. Charter fleet statistics from logbooks in 2003 and 2009 and observed trips in 2013.

		Survey	Private vessels		Charter vessels	
Blue cod		year	% Sub-legal	% Released	% Sub-legal	% Released
	Kaikōura	2003	40	40	6	29
		2009	28	36	9	23
		2013	47	50	8	9
	Motunau	2003	56	57	16	38
		2009	43	49	28	39
		2013	42	47	57	61

3.5.2 Sea perch

The observations of catch per trip collected from interviews are compared between seasons for each stratum (Table 32) and between years in (Table 33). The converse spatial distribution for sea perch is evident with catch rates on private vessels considerably greater at Kaikōura than at Motunau averaging almost 5 fish per vessel-hour, and not uncommonly 10 or more at Kaikōura, with about 80% of trips having a positive catch, but less than 1 fish per hour being more usual at Motunau, and 80% of trips unsuccessful (Figure 4).

The ACF ACR information available does not show the same differentiation between area for charter vessels (Table 34), but that is probably an artefact of the greater number of customers carried by the vessels operating from Motunau compared to Kaikōura.

Catch rates for sea perch appear to have declined with each successive survey in both areas, but not significantly (Table 33). The proportion of the catch released has also increased between 2009 and 2013 in each area (Table 35).

It is not possible to speculate whether the percentage of the catch of sea perch that was kept relates in any way to the size of the fish, because fish of any size may legally be kept for bait, and sea perch is commonly used for lobster bait.

Table 30: Comparison between areas and survey period of the mean number of sea perch caught per vessel-trip (total and legal) by private recreational vessels targeting blue cod or sea perch by lining in 2013. SD is the standard deviation of the observed catch of legal sea perch per trip, harvest rate estimate is the number of sea perch retained per vessel-hour (ratio of means).

		Catch per trip			
Location	Period	Total	Legal	SD	Harvest per vessel-hour
Kaikōura	Oct-Dec	12.8	12.8	14.9	3.142
	Jan-Apr	15.6	15.6	15.3	2.784
	May-Sep	18.3	18.3	20.2	3.201
Motunau	Oct- Dec	4.0	4.0	7.8	0.600
	Jan-Apr	3.0	3.0	6.5	0.396
	May-Sep	2.9	2.9	4.4	0.566

Table 33: Comparison between years and between areas of the mean number of sea perch caught per vessel-trip (total) by private vessels targeting blue cod or sea perch between January and April, standard deviation of the catch of sea perch per trip, catch rate estimate (number of sea perch per vessel hour: ratio of means). Results of one-way quasi-poisson GLM models between years with log-link, Pr(>t), significance of difference between years (n.s. is not significant).

Sea perch Private	Location	Survey year	Fish per vessel-trip All fish	(Std. dev.)	Fish per vessel-hour (ratio of means) All fish	p	Signif
	Kaikōura	2003	19.0	15.24	6.05		
		2009	16.6	15.58	5.15	0.0097	**
		2013	15.6	15.40	4.78	0.859	n.s.
	Motunau	2003	5.3	9.10	1.65		
		2009	4.0	7.50	1.17	0.17	n.s.
		2013	3.0	6.50	0.90	0.21	n.s.

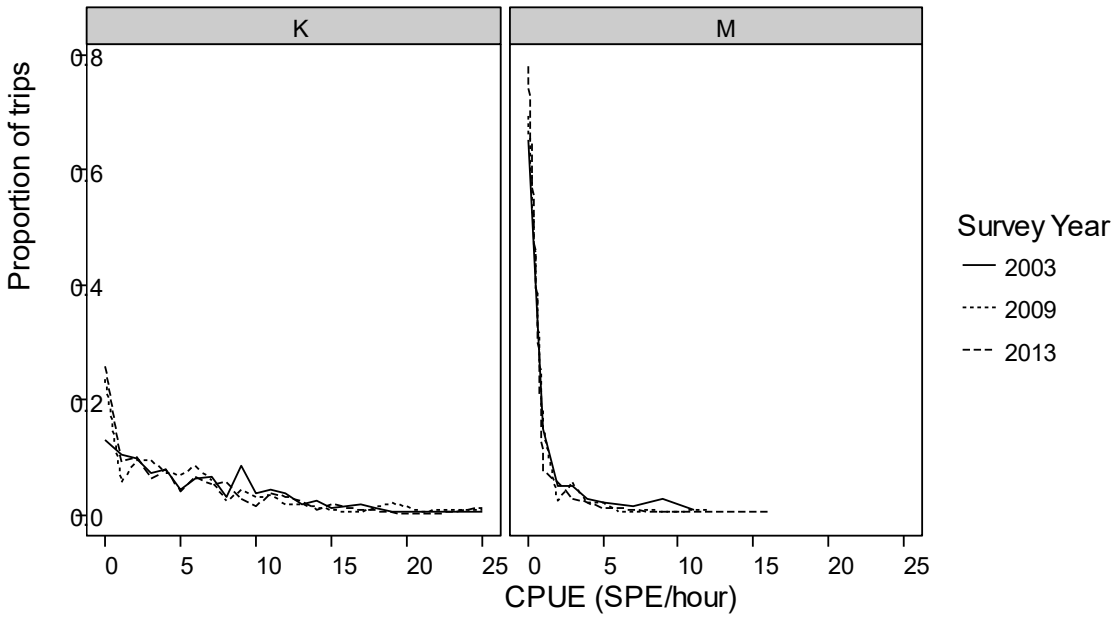

Figure 4: Distribution of catch rates (total number per vessel-hour) of sea perch from boat ramp surveys of the private vessel fleet at Kaikōura [left] and at Motunau [right] in 2003, 2009, and 2013.

Table 31: Catch rates of sea perch on (positive trips) by charter vessels from MPI Charter vessels activity Returns in 2012–13. Number of trips that reported a catch of sea perch, average number of sea perch caught per trip, average number of sea perch retained per trip, standard deviation (SD) of SPE harvest per trip.

Sea perch	Number of trips	Catch per trip Total	Retained	SD
Kaikōura	912	31.0	23.1	22.6
Motunau	91	44.9	30.2	22.0

Table 32: Proportion of reported catch of sea perch that was sub-legal (there is no MLS for sea perch) and the proportion of the total catch that was released for fleet, area, and survey year.

Sea perch				
Private		Survey year	% sub-legal	% Released
	Kaikōura	2003	–	30.6
		2009	–	36.0
		2013	–	42.0
	Motunau	2003	–	54.2
		2009	–	46.0
		2013	–	55.8

3.5.3 Rock lobster

Catch rates are expressed here as number of fish (total and legal) per trip for the two fishing methods (potting and diving), and harvest rate is the total number of lobster retained divided by the total number of pot lifts in each stratum (Table 36), or by the total number of fishers (Table 37).

Table 33: Comparison between areas and survey period of the mean number of lobster caught per vessel-trip (total and legal) by private recreational vessels targeting rock lobster by potting in 2013. SD is the standard deviation of the observed catch of legal rock lobster per trip, harvest rate estimate is the number of legal rock lobster retained per pot lift (ratio of means).

		Catch per trip			Harvest per pot lift
Location	Period	Total	Legal	SD	
Kaikōura	Oct-Dec	16.1	8.5	7.6	1.927
	Jan-Apr	12.2	6.9	7.5	1.745
	May-Sep	10.5	4.9	5.4	1.188
Motunau	Oct- Dec	9.1	8.0	5.6	1.981
	Jan-Apr	9.9	8.8	10.0	1.961
	May-Sep	2.5	1.4	1.2	0.524

Table 34: Comparison between areas and survey period of the mean number of lobster caught per vessel-trip (total and legal) by private recreational vessels targeting rock lobster by diving in 2013. SD is the standard deviation of the observed catch of legal rock lobster per trip, harvest rate estimate is number of legal rock lobster retained per diver (ratio of means).

		Catch per trip			
		Total	Legal	SD	Harvest per diver
Kaikōura	Oct-Dec	11.9	8.1	6.3	2.328
	Jan-Apr	10.8	8.1	6.5	2.447
	May-Sep	2.8	2.0	1.2	0.800
Motunau	Oct- Dec	15.0	12.7	8.3	3.698
	Jan-Apr	15.7	14.6	6.9	3.927
	May-Sep	12.3	12.3	9.0	3.267

3.6 Effectiveness of catch limits

Information about the catch that was released is necessarily based on the recall of at the end of the trip. It is presented here for completeness, and because it raises some questions about the effectiveness of catch limits. These data should be interpreted with some caution.

3.6.1 Blue cod

In both 2003 and 2009 a substantial proportion (52% and 40% respectively) of the private vessel catch was returned to the water as under-sized (Figure 5). This suggests that the MLS is an effective control on landed blue cod but also implies considerable potential for handling mortalities with as many sub-legal fish being handled and released as are kept. The charter fleet released a smaller proportion of their total catch as undersized in both years reflecting the larger size of fish that these operators access. In 2003, charter vessels voluntarily returned 18% of their legal size fish catch because the main operator exercised his own size limit. That operator was no longer in the fishery in 2009 and the behaviour of the charter fleet changed accordingly (Figure 5).

A larger proportion of the catch of blue cod was legal in 2009 than in 2003 with the effect that the bag limit was invoked on a greater proportion of trips (Figure 6) and there were some voluntary releases of legal size fish. These are further defined according to whether they were in excess of the bag limit or not, although this distinction may not describe different behaviours. Both these aspects were almost non-existent for the private vessel fleet in 2003. The difference in proportions kept and released between 2003 and 2009 for the charter fleet probably reflects the change in operators between years.

The bag limit constrained removals in fewer than 10% of private vessel vessel-trips in 2009, slightly higher than in 2003 (Figure 6). Charter operators achieved the vessel bag limit (10 per fisher) on 10 to 20% of trips and also returned a greater proportion of their legal catch than did private vessel anglers. This may partly explain the larger average size of their retained catch. The risk associated with up-sizing is that dead fish may be returned to the water, and the effectiveness of the bag limit therefore depends on the ethic of the fisher (*when* the decision is made to keep or return a fish). Both MLS and MDL controls have demonstrably negative consequences when fish are small as is the case in this fishery.

In 2013, the proportion of the catch that was sub-legal increased to 43% for both the private and charter fleets. The up-sizing reported in 2009 was absent in 2013 for the private fleet, with no records of legal fish in excess of the bag limit being returned, and a decline of this practice in the charter fleet from 9% in 2009 to 4% in 2013. The private fleet released 4% of legal size fish in 2013, up from 2% in 2009; whereas the observed charter vessels released less than 1% of legal size fish in 2013. For both fleets, the harvest was more often a smaller proportion of the bag limit in 2013 than it was in 2009, and the bag limit was achieved less often.

3.6.2 Rock lobster

In 2013, legal lobsters comprised 57% of the pot catch by private fishers, the bag limit was achieved on about 20% of potting trips, and fewer than 10% of trips were reported to have been unsuccessful. Despite this, there were few instances (less than 0.2%) of legal size fish that were in excess of the bag limit being returned to the water. Most of the legal lobster released (about 9% of the catch) were returned voluntarily, in that they don't appear to have been in excess of the bag limit (Figure 7, Figure 8).

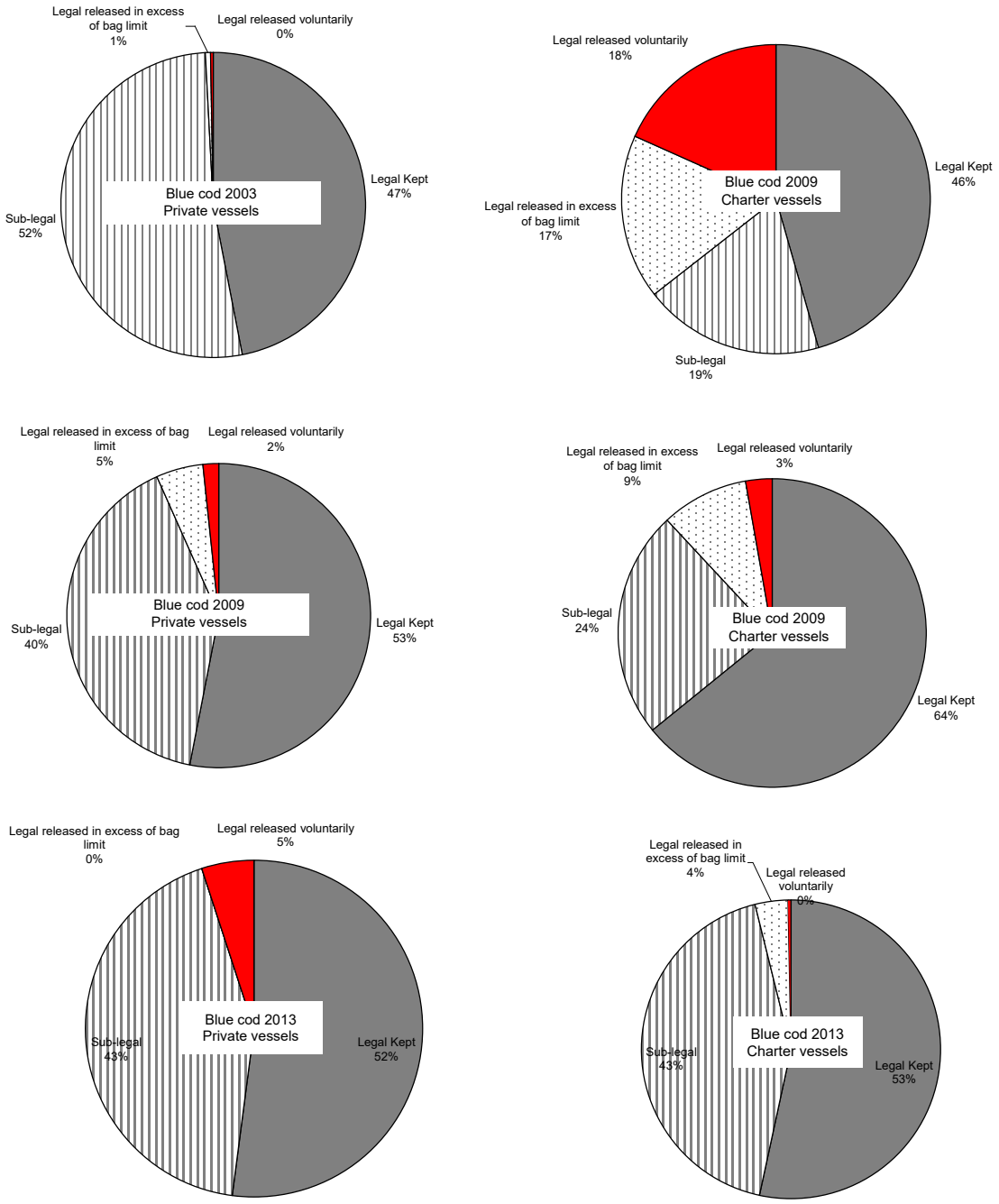

Figure 5: Proportions of blue cod kept [dark area], and released [other areas], from private vessels [left], and charter vessels [right], during January to April in 2003, 2009, and 2013 (observed). Fish released included undersized (sub-legal), legal fish in excess of the bag limit, and legal fish released voluntarily from vessels that retained less than the bag limit. Private vessels 2003, n=4351; charter vessels 2003, n= 5289; private vessels 2009, n=6961; charter vessels 2009, n= 6363, private vessels 2013, n=6457; charter vessels 2013, n= 620.

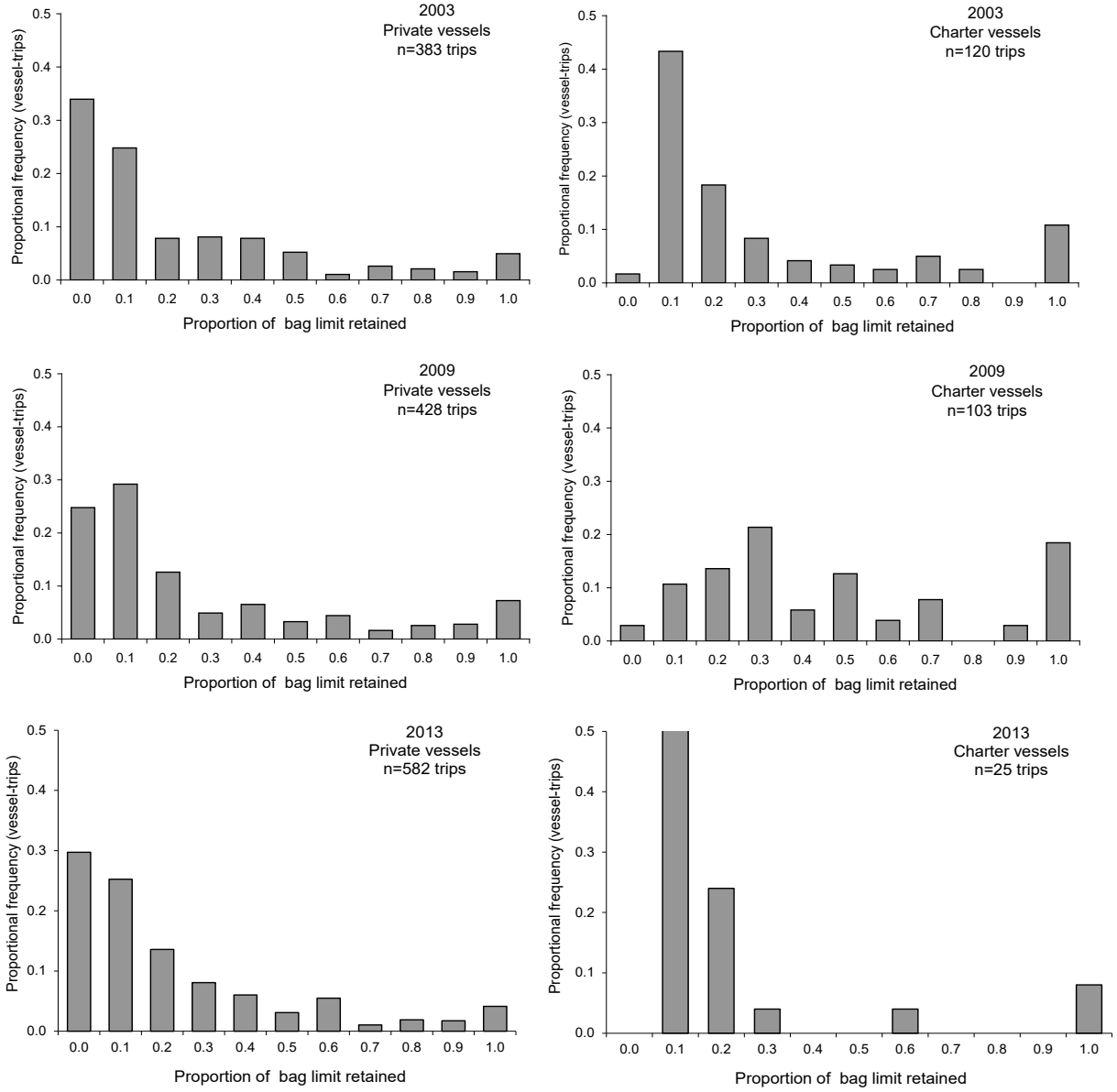

Figure 6: Distributions of harvested catch of blue cod as a proportion of vessel bag limits for private vessel [left] and charter vessels [right] in January to April of 2003, 2009, and 2013.

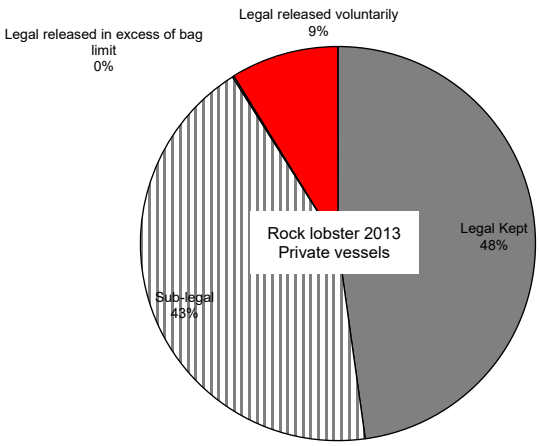

Figure 7: Proportions of pot-caught rock lobster kept [dark area], and released [other areas], from private vessels [left] in the 2012–13 fishing year. Fish released included undersized (sub-legal), legal fish in excess of the bag limit, and legal fish released voluntarily from vessels that retained less than the bag limit. n= 11 437.

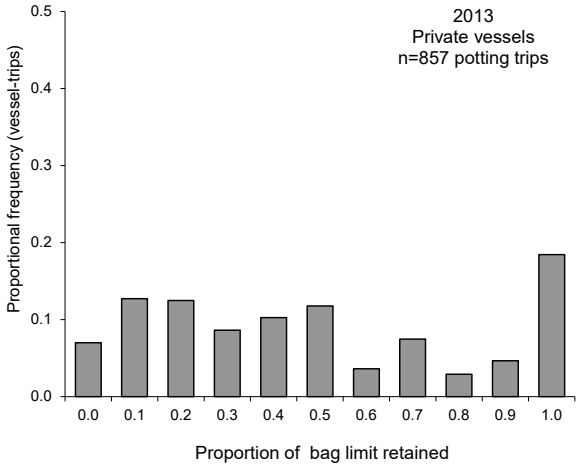

Figure 8: Distributions of harvested catch of pot-caught rock lobster as a proportion of vessel bag limits for private vessel in 2012–13 fishing year (both areas combined).

3.7 Fish size

In 2013 surveyors were unable to obtain the target number of fish measurements of 150 per species per area, per 4-month period. This was first raised as a problem during October to December 2012 with numbers of sea perch at Motunau and numbers of blue cod at Kaikōura particularly low, but although surveyors were aware of the requirements, the shortfall worsened in the following period as ramps got busier and fishers were under time pressure during vessel retrieval. Data for blue cod and sea perch are given in Tables 38–41.

Blue cod and sea perch were measured without regard to sex or method of capture, and mean lengths and number of fish measured are given for each area and season in Table 39 and Table 41. The mean weights are calculated from mean lengths using length-weight relationships given in Appendix 5 and have considerable leverage in the conversion of total harvest estimates (in numbers of fish) to kilograms greenweight. Comparisons made in this section among years are for the (survey) period January to April.

3.7.1 Blue cod (BCO)

The average size of blue cod retained by private vessel fishers at Kaikōura declined significantly (at p=0.001) between 2003 and 2009 by over 4 cm, but did not change at Motunau (Figure 9, Table 38). In 2013, there was a further decrease in the average size of blue cod harvested at Kaikōura (at p=0.05), but no significant change in the average size of blue cod harvested at Motunau.

The charter fleet experienced a similar decline in the average size of blue cod at Kaikōura as well as a smaller decline at Motunau between 2003 and 2009, but no further significant change in blue cod size was detected in 2013. In 2003, blue cod caught at Kaikōura by the private vessel fleet were considerably larger than those caught at Motunau (over 1 kg on average compared with 0.6 kg). By 2009, there was not such a marked difference, with the average size for Kaikōura blue cod having declined to almost the same as the Motunau caught fish.

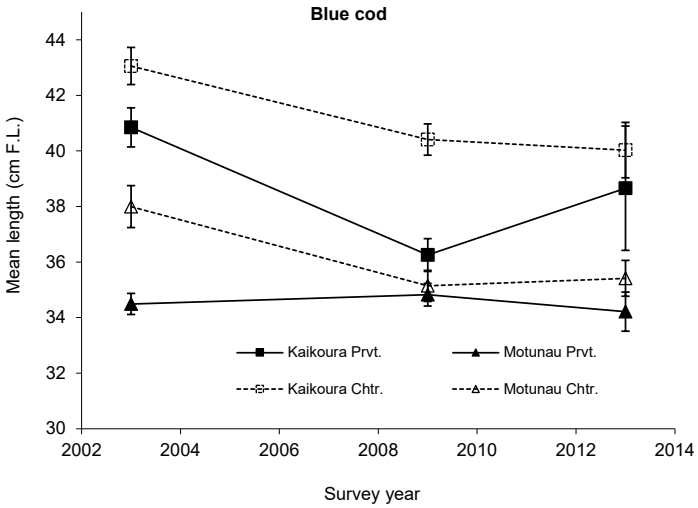

Figure 9: Comparison of mean lengths (± 2 SE) in 2003, 2009, and in 2013 of blue cod retained during the January to April period by the private vessel fleet and the charter fleet in Kaikōura and Motunau.

Table 35: Comparison of calculated mean weight (kg) and mean length (cm F.L.) of the retained catch of blue cod by fleet and area in 2003, 2009, and 2013. SE is standard error of mean length, p is Pr(>|t|) students-t difference between years, significance code where * =0.001, n.s. is not significant. % sub-legal is the percentage of the catch reported to have been smaller than MLS (30 cm) and released.**

Blue cod Fleet	Location	Survey year	Mean weight (kg)	Mean length (F.L.) cm	SE	p	Signif.	% sub-legal
Private vessel	Kaikōura	2003	1.10	40.8	0.35			40
		2009	0.76	36.3	0.29	<0.001	***	28
		2013	0.92	38.7	1.12	0.045	*	47
	Motunau	2003	0.65	34.5	0.19			56
		2009	0.67	34.8	0.20	0.233	n.s	43
		2013	0.63	34.2	0.35	0.134	n.s	42
Charter								
	Kaikōura	2003	1.29	43.1	0.33			6
		2009	1.06	40.4	0.28	<0.001	***	9
		2013	1.03	40.0	0.50		n.s.	8
	Motunau	2003	0.88	38.0	0.38			16
		2009	0.69	35.1	0.28	<0.001	***	28
		2013	0.70	35.4	0.32		n.s.	57

The changes in length structure of the retained catch for private vessels at Kaikōura between 2003 and 2009 (Figure 10) shows the loss of two distinct modes of larger fish (centred around 40 cm and 46 cm) that were present in 2003, and the appearance of a new peak of fish that were more recently recruited to the fishery (centred around 34 cm). In combination with the reported decline in the proportion of sub-legal fish in the catch this represented a marked contraction of the length distribution. Very few blue cod from Kaikōura were measured from the private fleet during the comparable period in 2013, but the mode was similar to that in 2009, at around 34 cm. Sub-legal fish comprised a greater proportion of the catch in 2013 than in 2009 and, when considered alongside the increase in total catch (but not legal catch), may indicate a pulse of pre-recruits to Kaikōura.

In 2009, the charter vessels operating from Kaikōura were still able to access larger blue cod, with a mode at 48 cm, but their retained catch was similarly dominated by a mode of smaller fish centred at 34 cm. In 2013 the mode is broader and comprises fish between 34 and 38 cm but confirms a generally similar size structure than that seen in 2009.

The size structure of the private vessel harvest of blue cod at Motunau was described as knife-edged in 2003 (Hart & Walker 2004) and looked very similar in 2009, with no accumulation of large fish evident. In 2013, the retained catch for the private fleet shows a more extreme mode close to the minimum legal size, with a small increase in the proportion of larger fish above 40 cm (Figure 11). Total catch rates were lower and the proportion of the catch that was sub-legal was similar to 2009.

The composition of the charter fleet retained catch was different from that of the private vessel fleet in 2003 with larger numbers of big fish represented, and this also was the case in 2009, but in 2013 the size structure has shifted to the left and included few of the larger fish seen previously (Figure 11).

Average lengths in each stratum were converted to weight using the relationship described in Appendix 5 and are given in Table 39.

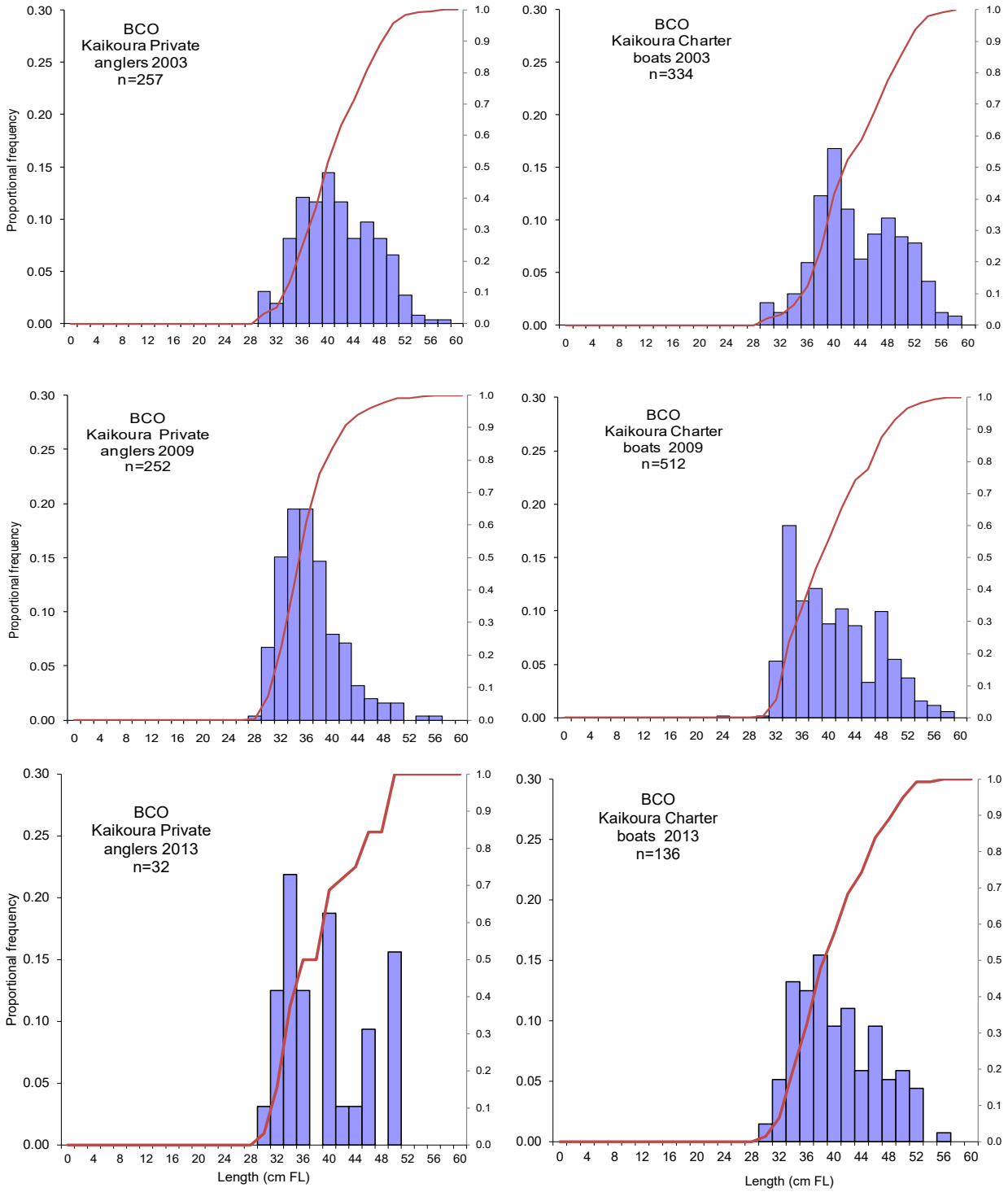

Figure 10: Length distributions (proportions and cumulative proportions) of retained blue cod from private vessels [left] and charter boats [right] fishing from Kaikōura in 2003, 2009, and 2013. The minimum legal size for blue cod in these areas was 30 cm.

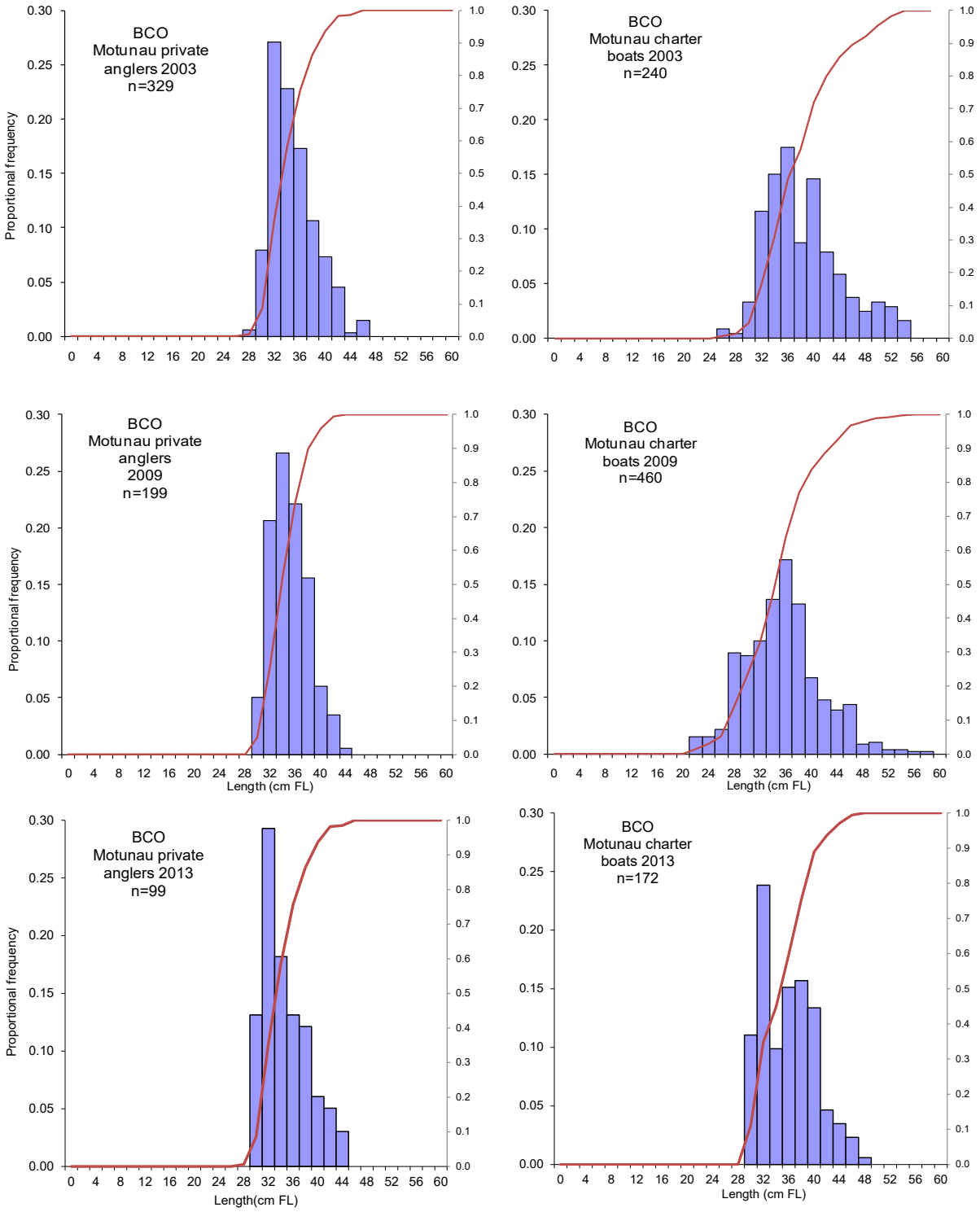

Figure 11: Length distributions (proportions and cumulative proportions) of retained blue cod from private vessels [left] and charter boats [right] fishing from Motunau in 2003, 2009, and in 2013. The minimum legal size for blue cod in these areas was 30 cm.

Table 36: Number of blue cod measured, average fork length (cm), and average calculated greenweight (g) by area / period, and for area overall.

Area	Period	n	Average fork length (cm)	Average calculated weight (g)
Kaikōura	Oct-Dec	36	37.7	852
	Jan-Apr	32	38.7	924
	May-Sep	10	38.4	905
Motunau	Oct-Dec	160	33.8	609
	Jan-Apr	99	34.2	631
	May-Sep	39	33.8	608
Kaikōura	whole year	78	38.2	888
Motunau	whole year	298	34.0	616

3.7.2 Sea perch (SPE)

The average size of sea perch retained by private vessel fishers declined significantly (at p=0.001) by more than 3 cm between 2003 and 2009 in Kaikōura, with no subsequent change in 2013 (Figure 12, Table 40), and no change between years detectable at Motunau.

The charter fleet experienced no similar decline and maybe a slight increase in both areas between 2003 and 2009, but a large decrease at Kaikōura in 2013 by about 7cm, with no change at Motunau.

In 2003, sea perch retained by the charter fleet at Kaikōura were considerably larger than those retained from Motunau. In 2009, the difference was even greater (over twice the average greenweight). By 2013 this distinction had disappeared. The numbers of sea perch measured from private vessels at Motunau were too few in 2009 and in 2013 to make any useful comparisons.

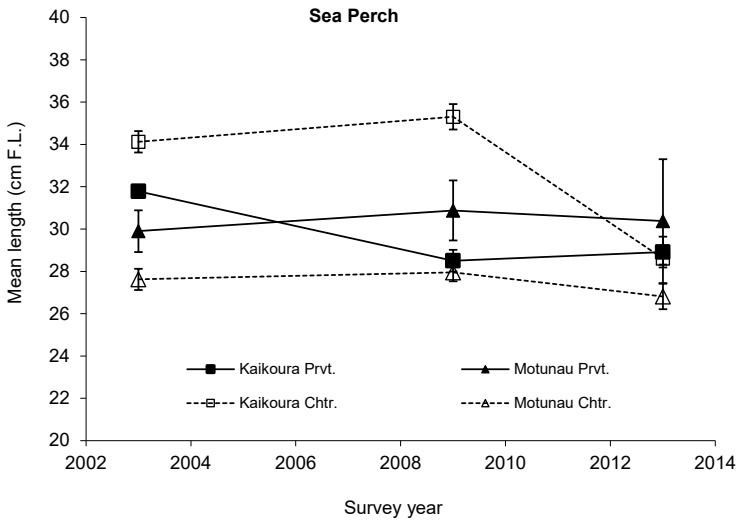

Figure 12: Comparison of mean length (± 2 SE) in 2003, 2009, and 2013 of sea perch retained by the private vessel and charter fleets in Kaikōura and Motunau.

Table 37: Comparisons of calculated mean weight (kg) and mean length (cm F. L.) of the retained catch of sea perch by fleet and area for the January to April period in 2003, 2009, and 2013. SE is standard error of mean length, p is Pr(>|t|) students-t difference between years, significance code where * =0.001, **=0.01, and n.s. is not significant.**

Sea perch	Location	Survey year	Mean weight (kg)	Mean length (cm F.L.)	SE	p	Signif.
Private	Kaikōura	2003	0.53	31.8	0.15		
		2009	0.38	28.6	0.26	<0.001	***
		2013	0.39	28.9	0.37	0.423	n.s.
	Motunau	2003	0.44	29.9	0.49		
		2009	0.49	30.9	0.71	0.263	n.s.
		2013	0.46	30.4	1.46	0.763	n.s.
Charter	Kaikōura	2003	0.67	34.1	0.25		
		2009	0.75	35.3	0.30	0.003	**
		2013	0.38	28.6	0.14	<0.001	***
	Motunau	2003	0.34	27.6	0.25		
		2009	0.35	28.0	0.21		n.s.
		2013	0.31	26.8	0.30		n.s.

The size structure of the harvest of sea perch by the private fleet at Kaikōura in 2003 was dome-shaped with a broad mode spanning 30 to 36 cm. In 2009 the shape was similar but shifted to the left by about 4 cm with a new mode centred around 20 cm. In 2013, the distribution changed from dome-shaped to knife-edged with a dominant mode at 26 cm (Figure 13). At Motunau, the sample of private vessel harvest of sea perch measured was too small in any year to be able to make comparisons.

The size structure of the catch of the charter fleet operating from Kaikōura showed considerable shifts between 2003 and 2009 despite there being little change in the mean length; whereas in 2003 it described a uni-modal distribution centred around 36 cm, in 2009 two modes were obvious, centred at 30 cm and at 40 cm. In 2013, the distribution is steeply centred on 30 cm (Figure 14).

At Motunau, the charter fleet catches looked similar in 2009 to 2003. Although the mode had shifted to the left by 1 cm, there was an accumulation of larger (30–36 cm) fish evident that accounted for the slightly greater average size in 2009 (Figure 14). In 2013 the distribution is similarly unimodal and centred on 24 cm, but with an accumulation of larger (30–36 cm) fish inflating the right hand side. It is not possible to speculate whether the percentage of the catch of sea perch that was kept relates in any way to the size of the fish, because fish of any size may legally be kept, and sea perch is commonly used for bait.

Average lengths in each stratum were converted to weight using the relationship described in Appendix 5 and are given in Table 41.

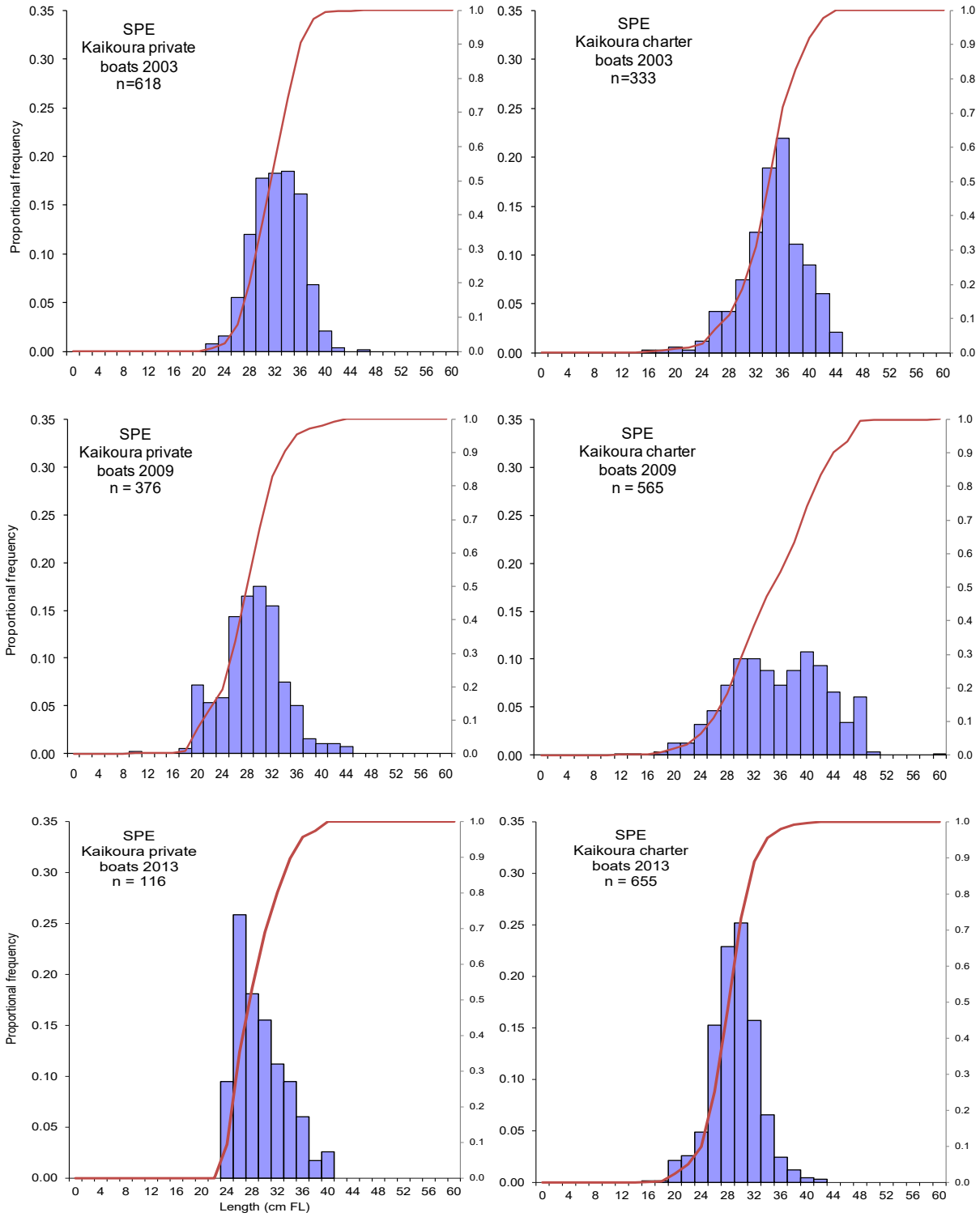

Figure 13: Length distributions (proportions and cumulative proportions) of retained sea perch on private vessels [left] and charter boats [right] fishing from Kaikōura in 2003, 2009, and in 2013.

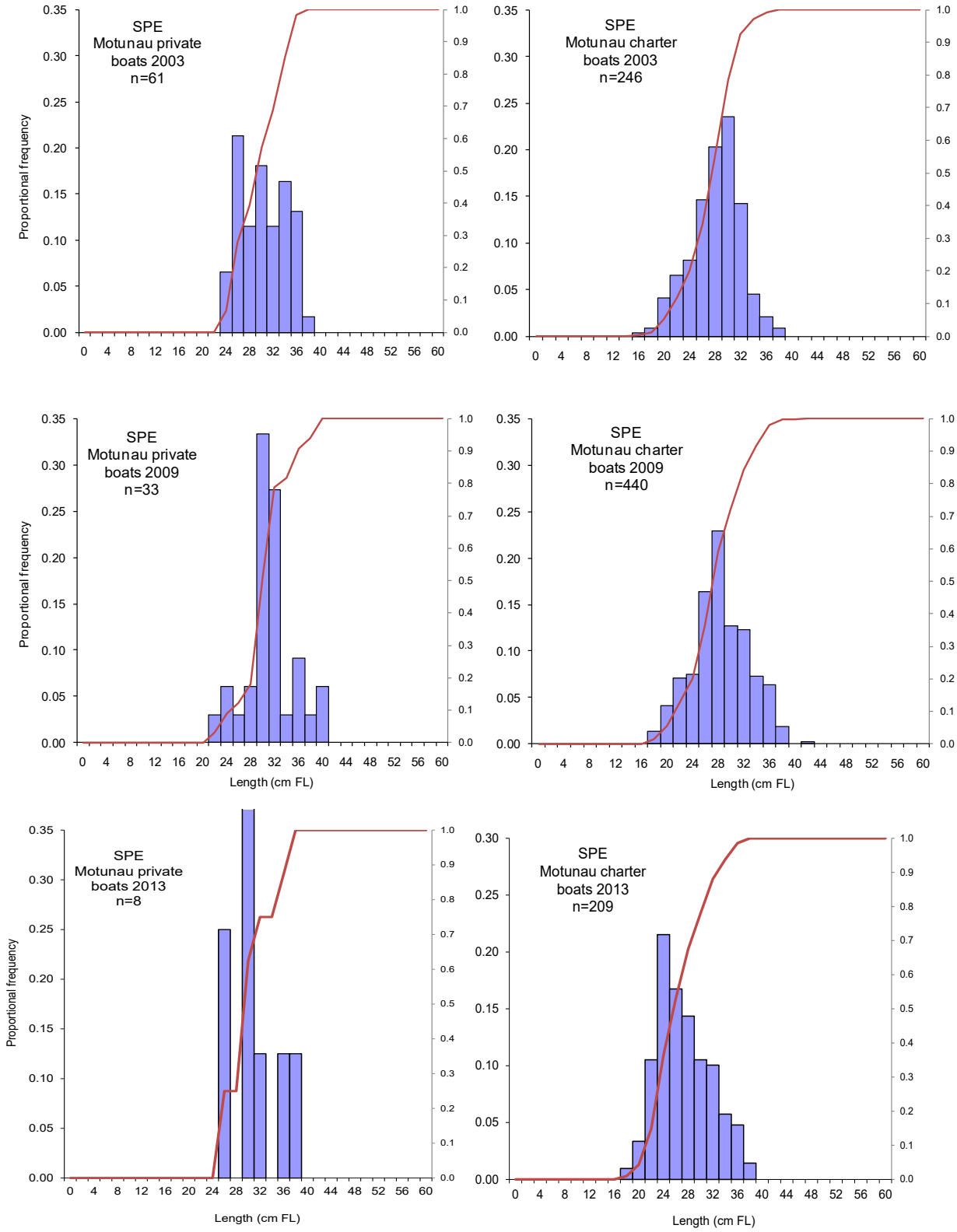

Figure 14: Length distributions (proportions and cumulative proportions) of retained sea perch on private vessels [left] and charter boats [right] fishing from Motunau in 2003, 2009, and in 2013.

Table 38: Number of sea perch measured, average fork length (cm), average calculated greenweight (g) by area / period, and for area overall.

Area	Period	n	Average fork length (cm)	Average calculated weight (g)
Kaikōura	Oct-Dec	235	28.7	383
	Jan-Apr	116	28.9	392
	May-Sep	23	30.3	456
Motunau	Oct-Dec	12	30.2	450
	Jan-Apr	8	30.4	460
	May-Sep	23	29.1	402
Kaikōura	whole year	374	28.9	390
Motunau	whole year	43	29.7	425

3.7.3 Rock lobster (CRA)

For lobster, the seasonal size distribution of the harvest at Kaikōura by private vessels is shown in Figure 15 and for Motunau in Figure 16. There are some large differences that may be in part due to a greater proportion of lobsters at Motunau being dive-caught, compared with Kaikōura where potting is more common, and also due to the catch being skewed towards males in the May to September period when females are in berry. The samples for Motunau appear too sparse however, to draw comparisons.

New tail width x weight relationships were calculated from the 291 undamaged lobsters for which we obtained both measurement and weight (described in Appendix 6). The mean tail width (mm) and number of lobster measured are given by fishing method, sex, area, and season in Table 42, and have been averaged across sex to describe lobsters measured in each stratum in Table 43. A very few lobsters from trips that reported both methods (potting and diving) will be included in both methods. Each measurement was converted using the tail width x weight relationships described in Appendix 5, and then averaged to estimate mean weight for each method /area / period, and over the whole year for each area. The numbers and proportions of lobster measured are small and unlikely to be representative of the catch in each stratum, and the annual mean weights by method and area were used to estimate total harvest in greenweight from the estimated numbers of lobster.

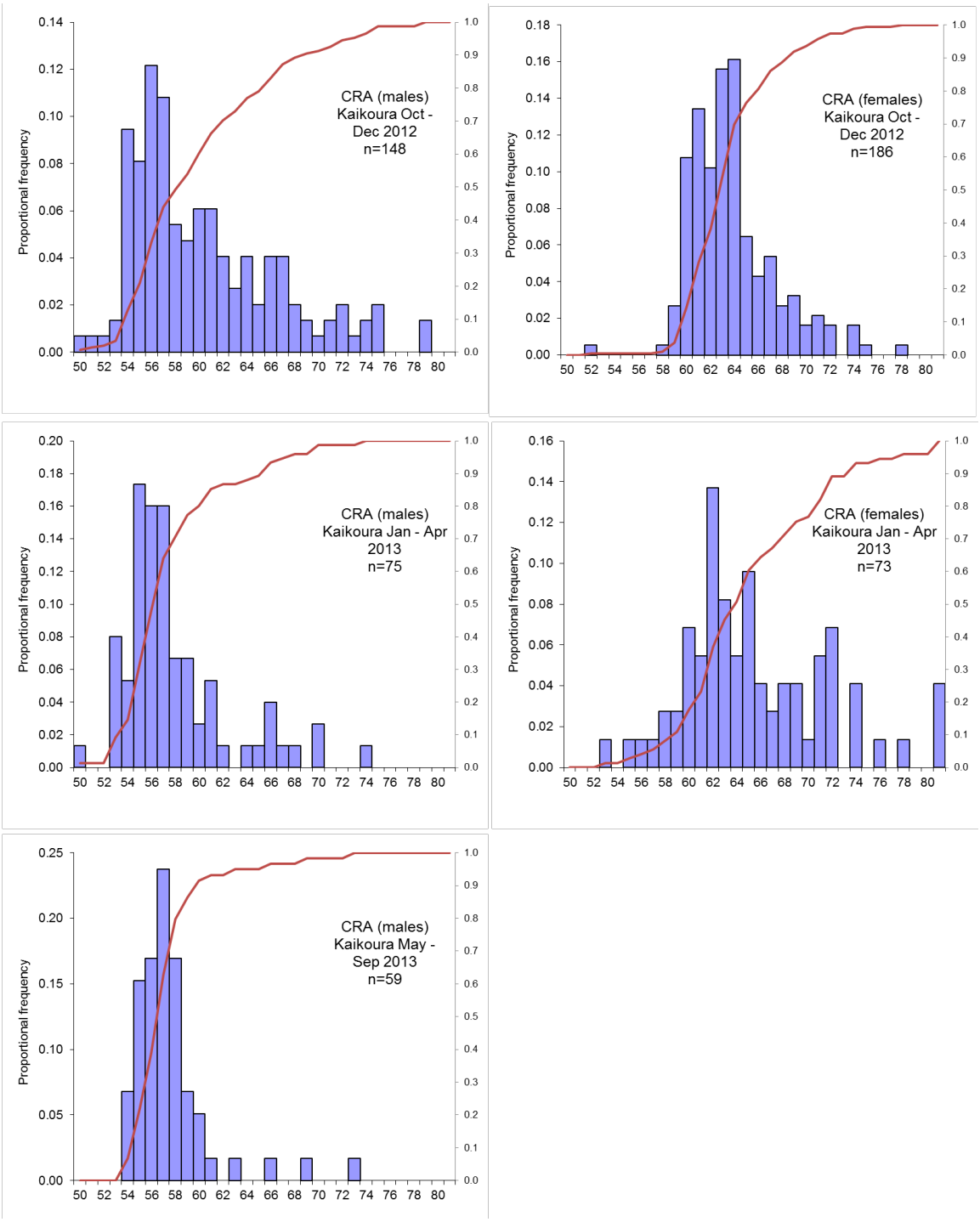

Figure 15: Length distributions (proportions and cumulative proportions) of retained rock lobster by sex from private vessels fishing from Kaikōura in 2013. Measurements obtained during the main survey period of January to April are described in the middle two panels. Prevalence of females in berry in the May-September period accounts for the low numbers of females retained.

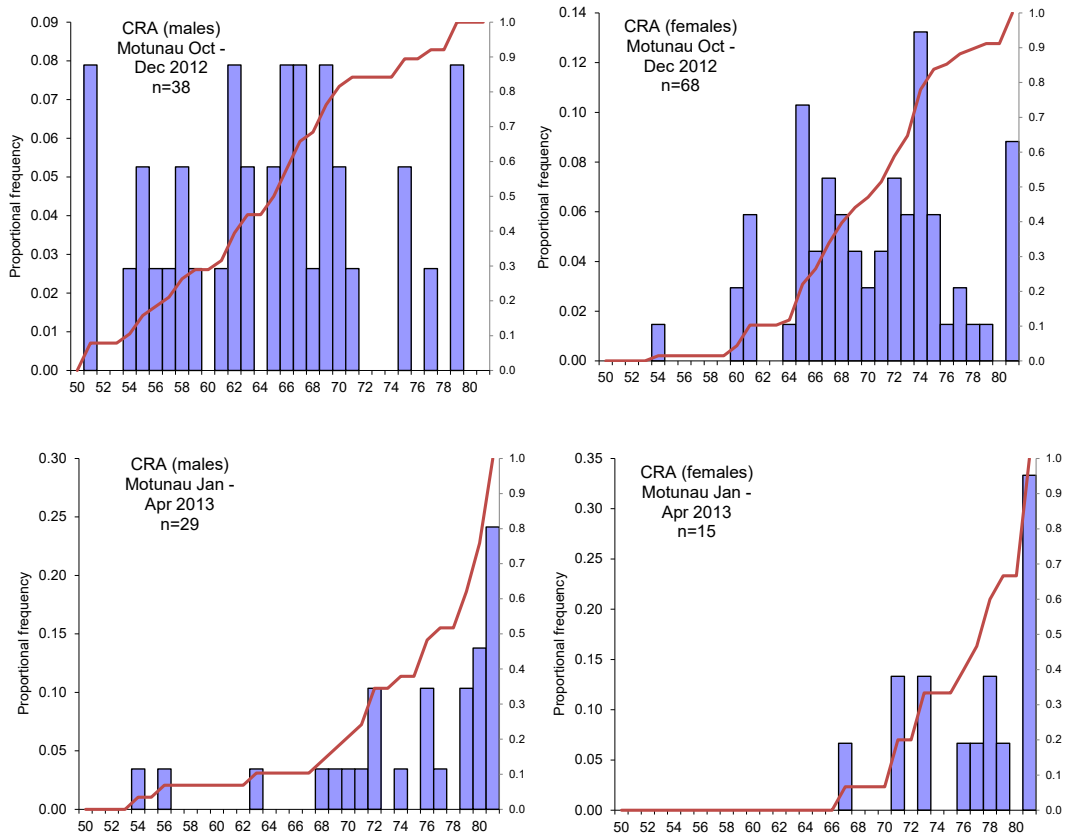

Figure 16: Length distributions (proportions and cumulative proportions) of retained rock lobster by sex from private vessels fishing from Motunau in 2013. Measurements obtained during the main survey period of January to April are described in the lower two panels. Only three lobster (not shown) from Motunau were measured in the last period (May to September). Prevalence of females in berry (which may not be retained) in the May-September period accounts for the low numbers of females retained.

Table 39: Numbers of lobster measured, average tail width (mm), average calculated greenweight (g), by fishing method/location/period/sex.

		Males			Females		
	Period	n	Average tail width (mm)	Average calculated weight (g)	n	Average tail width (mm)	Average calculated weight (g)
Pot-caught							
Kaikōura	Oct-Dec	132	60.2	719	179	63.9	522
	Jan-Apr	67	57.9	625	48	64.5	537
	May-Sep	54	57.4	599	1	67.0	588
Motunau	Oct-Dec	10	64.5	895	15	71.9	716
	Jan-Apr	1	84.0	2029	1	71.0	685
	May-Sep	2	76.5	1520	0	–	–
Dive-caught							
Kaikōura	Oct-Dec	18	61.3	765	7	62.6	493
	Jan-Apr	13	58.5	647	29	67.7	621
	May-Sep	5	59.6	704	0	–	–
Motunau	Oct-Dec	28	64.7	927	53	70.5	685
	Jan-Apr	28	75.8	1524	14	77.7	878
	May-Sep	1	63.0	803	0	–	–

Table 40: Number and average tail width of pot-caught lobsters measured for fishing method / area / period converted to greenweight. Average weights were used to estimate total harvest.

	Period	n	Average tail width (mm)	Average calculated weight (g)
Pot-caught				
Kaikōura	Oct-Dec	311	62	606
	Jan-Apr	115	61	588
	May-Sep	55	58	599
Motunau	Oct-Dec	25	69	788
	Jan-Apr	2	78	1 357
	May-Sep	2	77	1 520
Kaikōura	whole year	481	61	601
Motunau	whole year	29	70	877
Dive-caught				
Kaikōura	Oct-Dec	25	62	689
	Jan-Apr	42	65	629
	May-Sep	5	60	704
Motunau	Oct-Dec	81	68	769
	Jan-Apr	42	76	1 309
	May-Sep	1	63	803
Kaikōura	whole year	72	63	655
Motunau	whole year	124	68	952

3.8 Annual harvest (private recreational vessels)

Total harvest (number of fish retained) was estimated for each sampled day using the estimated daily effort (vessel-hours) expanded up from trailer counts on the Kaikōura bus route and, as observed at Motunau, multiplied by the number of fish retained per vessel-hour from boat ramp interviews. Daily estimates of total catch and associated variance were scaled up to the number of days in each stratum to obtain total harvest estimates. A summary of these estimates for individual strata, combined across day type for each period in each area, and combined across period for each area, are given for blue cod in Table 44, for sea perch in Table 45, and for pot-caught rock lobster in Table 46, and for dive-caught lobster in Table 47.

3.8.1 Blue cod

Table 41: Calculation of total harvest (number of blue cod retained) in private vessel recreational fishing for the 2012–13 fishing year: days sampled and total days in stratum, average harvest per day with standard deviation, estimate of total harvest per stratum and standard error, and estimated total harvest (standard error, CV) by area / period, and by area (whole year).

Blue cod			Sampled	Stratum	Mean		By stratum		By area/period			By area		
Location	Period	Day type	days	days	catch/day	SD	Catch	SE	Catch	±(SE)	% CV	Catch	±(SE)	% CV
Kaikōura	Oct-Dec	Weekday	17	59	35.38	99.3	2 087	1 199	3 547	1 229	34.7			
		Weekend	13	33	44.22	38.1	1 459	271						
	Jan-Apr	Weekday	21	78	25.10	56.5	1 958	822	6 590	1 032	15.7	11 466	1 664	14.5
		Weekend	18	42	110.28	83.5	4 632	625						
	May-Sep	Weekday	15	108	6.35	14.3	686	371	1 329	441	33.2			
		Weekend	10	45	14.30	19.1	643	239						
Motunau	Oct-Dec	Weekday	2	59	74.49	7.6	4 395	313	7 244	724	10.0			
		Weekend	13	33	86.32	91.6	2 849	653						
	Jan-Apr	Weekday	3	78	37.73	56.1	2 943	2 476	7 728	2 670	34.6	16 649	2 838	17.1
		Weekend	17	42	113.93	127.5	4 785	1 002						
	May-Sep	Weekday	2	108	7.11	5.3	768	404	1 677	634	37.8			
		Weekend	9	45	20.20	36.4	909	489						

3.8.2 Sea perch

Table 42: Calculation of total harvest (number of sea perch retained) in private vessel recreational fishing for the 2012–13 fishing year: days sampled and total days in stratum, average harvest per day with standard deviation, estimate of total harvest per stratum and standard error, and estimated total harvest (standard error, CV) by area / period, and by area (whole year).

Sea perch			Sampled	Stratum	Mean		By stratum		By area /period			By area		
Location	Period	Day type	days	days	catch/day	SD	Catch	SE	Catch	±(SE)	% CV	Catch	±(SE)	% CV
Kaikōura	Oct-Dec	Weekday	17	59	65.60	104.0	3 870	1255	13 466	2170	16.1			
		Weekend	13	33	290.78	248.6	9 596	1771						
	Jan-Apr	Weekday	21	78	90.35	130.8	7 047	1904	27 070	4 066	15.0	50 242	5 404	10.8
		Weekend	18	42	476.74	480.1	20 023	3593						
	May-Sep	Weekday	15	108	47.35	74.1	5114	1918	9 706	2 822	29.1			
		Weekend	10	45	102.05	164.9	4592	2070						
Motunau	Oct-Dec	Weekday	2	59	16.10	0.0	950	0	1 439	131	9.1			
		Weekend	13	33	14.81	18.4	489	131						
	Jan-Apr	Weekday	3	78	7.84	11.6	612	513	1209	532	44.0	2 840	554	19.5
		Weekend	17	42	14.23	18.0	598	141						
	May-Sep	Weekday	2	108	0.00	0.0	0	0	192	85.	44.0			
		Weekend	9	45	4.27	6.3	192	85						

3.8.3 Rock lobster

Table 43: Calculation of total harvest (numbers of rock lobster retained) by private vessel recreational fishing by potting for the 2012–13 fishing year: days sampled and total days in stratum, average harvest per day with standard deviation, estimate of total harvest per stratum and standard error, and estimated total harvest (standard error, CV) by area / period, and by area (whole year).

Rock lobster			Sampled	Stratum	Mean		By Stratum		By area /period			By area		
Location	Period	Day type	days	days	catch/day	SD	Catch	SE	Catch	±(SE)	% CV	Catch	±(SE)	% CV
Kaikōura	Oct-Dec	Weekday	17	59	184	209	10 885	2 518	26 858	4081	15.2			
		Weekend	13	33	484	451	15 973	3 212						
	Jan-Apr	Weekday	21	78	114	170	8 858	2 473	22 501	3359	14.9	53 862	5 400	10.0
		Weekend	18	42	325	304	13 643	2 274						
	May-Sep	Weekday	15	108	22	26	2 388	671	4 503	1102	24.5			
		Weekend	10	45	47	70	2 116	873						
Motunau	Oct-Dec	Weekday	2	59	25	3	1 475	116	2 138	194	9			
		Weekend	13	33	20	22	663	156						
	Jan-Apr	Weekday	3	78	5	8	364	357	1 202	412	34	3 443	459	13
		Weekend	17	42	20	26	838	206						
	May-Sep	Weekday	2	108	1	1	54	53	104	58	56			
		Weekend	9	45	1	2	50	22						

Table 44: Calculation of total harvest (number of rock lobster retained) in private vessel recreational fishing by diving for the 2012–13 fishing year: days sampled and total days in stratum, average harvest per day with standard deviation, estimate of total harvest per stratum and standard error, and estimated total harvest (standard error, CV) by area / period, and by area (whole year).

Rock lobster			Sampled	Stratum	Mean		By stratum		By area /period			By area		
Location	Period	Day type	days	days	catch/day	SD	Catch	SE	Catch	±(SE)	% CV	Catch	±(SE)	% CV
Kaikōura	Oct-Dec	Weekday	17	59	4	12	229	150	1 011	287	28			
		Weekend	13	33	24	34	783	245						
	Jan-Apr	Weekday	21	78	3	5	200	79	2 768	440	16	3 902	530	14
		Weekend	18	42	61	58	2 569	433						
	May-Sep	Weekday	15	108	0	2	48	45	122	63	51			
		Weekend	10	45	2	3	74	43						
Motunau	Oct-Dec	Weekday	2	59	71	66	4 189	2 726	6 702	2801	42			
		Weekend	13	33	76	90	2 513	644						
	Jan-Apr	Weekday	3	78	16	15	1 248	667	5 003	919	18	12 489	2 974	24
		Weekend	17	42	89	81	3 755	633						
	May-Sep	Weekday	2	108	3	4	324	321	784	395	50			
		Weekend	9	45	10	17	460	231						

Note: 52% of the Kaikōura pot-caught lobsters were landed in trips finishing 10:00 a.m. or later. All dive-caught lobsters were landed 10:00 a.m. or later.

3.9 Total annual harvest

Estimates of the total annual harvest for the 2012–13 fishing year in numbers of fish are given in Table 48. The mean size of the retained catch and published length-weight relationships (Appendix 5) also allowed estimation of the total weight of removals in kilograms greenweight (Table 49), but they are subject to the representativeness of average size of the harvest estimated from measurements obtained.

Total annual harvest estimates also include catches reported by charter operators on the Amateur Vessel Activity Form. Reporting of lobster is mandatory, but blue cod and sea perch catches were also reported by skippers of vessels operating out of either Kaikōura or Motunau. Operators also voluntarily estimated the total weight of retained catch for each species.

Table 45: Summary of total harvest (numbers of fish) by amateur fishing, of blue cod, sea perch, and rock lobster in 2012–13 from Kaikōura and Motunau, for private vessels (estimated) and charter vessels (reported).

		Amateur estimated harvest	±S.E.	Charter reported harvest	Total fish
BCO	Kaikōura	11 466	1 665	5 668	41 632
	Motunau	16 649	2 839	7 849	
SPE	Kaikōura	50 242	5 405	21 031	76 864
	Motunau	2 840	555	2 751	
CRA (potting)	Kaikōura	53 862	5 405	5 817	63 994
	Motunau	3 443	459	872	
CRA (diving)	Kaikōura	3 902	530		16 391
	Motunau	12 489	2 974		

Table 46: Summary of total harvest (kg greenweight) by amateur fishing, of blue cod, sea perch, and rock lobster in 2012–13 from Kaikōura and Motunau, for private vessels (estimated using average fish size) and charter vessels (estimated by skipper).**

		Mean weight used	Amateur estimated harvest	Charter reported harvest **	Total (kg)
BCO	Kaikōura	887.56	10 177	5 583	31 701
	Motunau	616.31	10 261	5 680	
SPE	Kaikōura	389.82	19 585	9 898	32 228
	Motunau	425.36	1 208	1 536	
CRA (potting)	Kaikōura	600.72	32 356	3 964	54 557
	Motunau	877.46	3 021	770	
CRA (diving)	Kaikōura	655.07	2 556		
	Motunau	952.02	11 890		

3.10 Comparison with previous years (January to April)

Comparisons between years are possible for estimates of private line fishing effort and private vessel harvest of blue cod and sea perch over the comparative period January to April (Table 50).

There was a 60% increase in the number of blue cod taken between 2003 and 2009, corresponding closely with the estimated increase in effort and converting to a 40% increase in biomass because of the decline in fish size at Kaikōura. The number of sea perch taken increased by 30% and equated to a 10% decrease in the biomass between 2003 and 2009.

In 2013, effort is estimated to have increased by a further 56% with an increase in the associated harvest of blue cod of almost 5% (in numbers) and 15% in biomass. The harvest of sea perch increased in 2013 by 21% in numbers and 25% in biomass (Table 50).

Table 47: Estimated total removals of blue cod and sea perch by private vessel recreational fishing in January-April for 2003, 2009, and in 2013. Relevant effort ± SE, numbers of fish kept ± SE, estimated greenweight kept (kg). Estimates for 2003 and 2009 have been reworked and differ from those published in previous reports.

Species	Survey year	Total effort (vessel-hours ± SE)	Number of fish kept (± SE)	Estimated greenweight of fish kept (kg)
BCO	2003	5 021 (571)	6 662 (1 225)	5 235
	2009	8 684 (1 459)	13 640 (3 311)	9 542
	2013	13 558 (1 446)	14 318 (2 863)	10 966
SPE	2003	5 021 (571)	16 574 (4 014)	8 719
	2009	8 684 (1 459)	23 246 (4 742)	8 894
	2013	13 558 (1 446)	28 279 (4 101)	11 168

4. DISCUSSION

This survey monitored changes in recreational catch rates and changes in harvest size distribution for blue cod and sea perch in the North Canterbury–Kaikōura area by surveying boat ramps at Motunau and Kaikōura.

The emphasis of the survey design was on obtaining total coverage of line fishing effort along the coast targeted at blue cod and/or sea perch, as well as obtaining length measurements for the harvest of both species. Harvest rate estimates in numbers of fish per vessel-hour were used to estimate total removals for each species. New equations were used in this study to estimate the total harvest and its standard errors from estimates of daily harvest; there are probably underestimates because they do not take into account the variance of catch rates at vessel-trip level. This is, however, in line with what is currently done for other boat ramp surveys including the most recent CRA 1 survey (Holdsworth 2014). Estimates of total harvest for 2003 and 2009 have been reworked using the methodology described by this report; this has resulted in similar point estimates but much smaller standard errors. They will therefore vary from what has been published previously, though without altering any conclusions drawn.

The total harvest estimates are converted to biomass using length-weight relationships, and their accuracy is largely determined by the mean size to which they are applied. The numbers of fish measured in each stratum may be inadequate to describe actual seasonal differences, and so overall mean size in each area was used for blue cod and for sea perch and the confidence bounds of harvest in weight is undetermined. For lobster the size differences are greater and more likely to be real because of differences between the size of dive-caught compared with pot-caught lobsters (which manifests as

an area difference because diving is the prevalent method employed from Motunau whereas potting is more common around Kaikōura) and also because of seasonal differences in the proportion of females in the harvest. The estimates of the weight of the harvest of lobster are based on the mean size of measurements obtained for each method in each area and assume that measured lobsters were representative of the harvest with respect to sex and season.

Although harvest rates can be verified by counting the catch retained at the boat ramp, this statistic does not tell us much about the fishery where fishers are voluntarily releasing part of their legal catch. Interviews were used to obtain estimates of total catch rate and of the proportion of catch that was of legal size (in the case of blue cod). Trip duration, used as the measure of effort for CPUE of finfish, was also obtained from interviews. Bias associated with fisher recall was not evaluated.

Catch estimates do not include shore based fishing, and negative biases will include other missed effort (where vessels are launched or retrieved from other localities) and days where the sampled catch was zero (because they are expanded up to an estimate of zero total daily catch, which is probably unrealistic).

4.1 Survey results

The estimates of total effort describe a further large (more than 50%) increase in private vessel effort targeted at blue cod or sea perch at Kaikōura between 2009 and 2013, particularly on weekends, and a smaller increase at Motunau, mostly on weekdays. The relative importance of the two areas (79% and 21% respectively) confirms a continuing shift in the relative importance of effort towards Kaikōura. The majority of vessels launched from Kaikōura boat ramps, however, were fishing for lobster, generally by potting, and an increasing proportion of vessels launched from Motunau in 2013 were targeting lobster; more often by diving. We found no evidence that refugees from the Marlborough blue cod fishery were adding to the fishing pressure in Kaikōura or Motunau.

Catch rates are subject to bias because they are based on fisher recall, but the proportion of the catch of blue cod that was below legal size appears to have increased (despite the average size of the retained catch having increased) and that is corroborated by an increase in zero catches, and a decrease in the number of trips that caught the bag limit. Private fishers continue to exercise their own minimum size and to voluntarily release legal fish. The increase in the number of sub-legal fish, when considered alongside the increase in the total (but not in the legal) catch per hour, points to an imminent recruitment to the fishery or at least a return to a more normal situation (than in 2009). A small (but not statistically significant) increase in the average size of retained blue cod at Kaikōura, along with changes in the size distribution of the catch by both private and charter vessels, suggests there has been some accumulation of fish from previously good recruitment.

Catch rates of sea perch continued to decline at both locations but not (statistically) significantly, and the size distributions of the harvest also point to modes of smaller fish than have previously been seen, although average size had not changed significantly for the private fleet. Anglers have responded by releasing a greater proportion of their catch than in previous surveys. A large and significant decline in average fish size kept on charter vessels is more likely to be an artefact of the small sample in 2013 (30 trips) and changes in the fleet from year to year, than in the underlying population of sea perch.

Few trends in charter fishing can be described in this transitional year (from collecting logbook data to analysing ACV returns).

With average fish size now hard up against the MLS, it is unlikely that any further decreases in fish size will be able to be demonstrated statistically, and the emphasis will turn to monitoring catch rates and the proportion of catch that is sub-legal to assess changes in the underlying population.

Evidence of previous high levels of recruitment to the blue cod fishery are still evident in the size structure of the harvest, particularly at Kaikōura, but recruitment at that level has not been maintained

so that in 2013, line fishers found it more difficult than in 2009, to achieve bag limits. Catch rates of legal size blue cod declined slightly at both Kaikōura and Motunau, but higher total catch rates and an increase in the proportion of sub-legal fish at Kaikōura may point to the imminence of a further good recruitment there. The same signals are not apparent at Motunau.

Total harvest estimates of lobster from this study are high compared with results from the 2011–12 national panel survey. However, local Kaikōura lobster potters and local dive fishers were not represented in the panel survey because, by chance, no mesh blocks were selected from the Kaikōura area (Wynne-Jones et al. 2014), which would account for the much lower estimates from that survey. Inter-annual variation in catch must also be considered because recreational harvest in a particular season is driven by a combination of factors of which stock abundance is only one.

4.2 Implications

Evidence of previous high levels of recruitment to the blue cod fishery are still evident in the size structure of the harvest, particularly at Kaikōura, but recruitment at that level has not been maintained so that in 2013 line fishers found it more difficult than in 2009 to achieve bag limits. Catch rates of legal size blue cod declined slightly at both Kaikōura and Motunau, but higher total catch rates and an increase in the proportion of sub-legal fish at Kaikōura may point to the imminence of a further good recruitment there. The same signals are not apparent at Motunau.

Catch rates of sea perch declined at both Kaikōura and Motunau, and, though there was a shift in the mode by 4 cm to the left in 2013 compared with 2009, very few fish that were smaller than that were retained, so the mean size of fish harvested by the private fleet did not change. There was, however, a large decrease in the mean size kept by the charter fleet, but that could also signal a shift in fisher behaviour rather than in the underlying population of sea perch.

Recreational catch limits for blue cod (MLS and MDL) each have biologically deleterious effects in a fishery consisting mostly of small fish. The MLS means that almost half the catch is returned to the water and is therefore subject to handling mortality (which could be as high as 100%, though it is probably much lower), and the MDL is either not constraining the fishery because it is rarely achieved (as in 2003), or, when abundance increases (as at Motunau in 2009), encourages up-sizing that may see dead fish returned to the water.

If recruitment is not maintained at previous high levels, it is likely that catch rates of both total and legal size fish will decline. There is not a large range of alternative species available to line fishers on this coast and this is likely to erode the experience of the amateur fisher.

4.3 Te Korowai

We would to thank Te Korowai o Te Tai o Marakura for their support with this project. The monitoring of recreational fishing has been, and is critical to, the sustainable management of the key recreational species of blue cod, sea perch, and rock lobster. The Kaikōura Marine Management Act 2014 came into force in early August 2014 and specific rules have been introduced for each of the species targeted in this project. These rules include:

- Blue cod – maximum daily limit reduced from 10 to 6/ fisher and a minimum size increase from 30 to 33 cm.
- Sea perch – introduction of a daily limit of 20/ fisher and the introduction of a minimum size of 26 cm.
- Rock lobster – introduction of an accumulation limit of 18 and telson clipping of recreational catch.

The Kaikōura Recreational Fishing project will provide baseline data from which the effectiveness of these strategies can be measured.

4.4 Recommendations for future surveys

Estimates of total harvest in numbers of fish are based on daily total removals which are themselves estimates. The confidence bounds are probably therefore underestimated but are comparable to what is done in other current surveys of recreational harvest. The estimates could be bootstrapped, but that wouldn't necessarily yield more defensible confidence bounds if the bootstrapping is done at the same level of resolution.

The Working Group may, in the future, decide it best to follow a two-level bootstrapping approach for bus route surveys by bootstrapping days within temporal strata, and, within each day by bootstrapping the boats encountered within each bus stop's session for that day. That would capture some of the uncertainty associated with the estimate for each day but should be part of a standardised approach across surveys, perhaps done as a sensitivity to turning the second level of bootstrapping on and off.

More work should be done to develop robust tail width to weight relationships for more general use (e.g., stock assessment), using more sophisticated modelling (e.g., hierarchical mixed models and parameter priors), and more data. For this study, the representativeness of sampling is probably more critical to establishing average weights.

5. ACKNOWLEDGMENTS

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APPENDIX 1: Example bus route schedule

Direction: 0=down
1=up

					Travel Times		
Identifier	Boat Ramp	Effort Weighting	Minutes	**Time spent at Boat Ramp**	Identifier	Times North	Times South
1	Boat Harbour	0.02	8	0:08	1	0:25:00	0:10:00
2	Pier Slipway	0.02	8	0:08	2	0:05:00	0:25
3	Armers Beach	0.08	33	0:32	3	0:10:00	0:05:00
4	Public Ramp	0.45	185	3:04	4	0:05:00	0:10:00
5	Boat Club	0.35	144	2:23	5	0:15:00	0:05:00
6	Barney's Rock	0.08	33	0:32	6	0:10:00	0:15:00
		1.00	410.00	6:47		1:10:00	1:10:00

Sample Day		**Direction ***	**Start Boat Ramp**	**Start times**	**Depart Times**
31	Sunday, 8 March 2009	0	2	10:00 a.m.	10:08 a.m.
			1	10:33 a.m.	10:41 a.m.
			6	10:51 a.m.	11:23 a.m.
			5	11:38 a.m.	2:01 p.m.
			4	2:06 p.m.	5:10 p.m.
			3	5:20 p.m.	6:00 p.m.

APPENDIX 2: Session and interview questionnaires used in the boat ramp surveys

Session sheet

BCO/SPE Boat ramp survey

Session cover sheet

Survey Code	
Interviewer	

Date:	

Ramp:	WB	R	AB	PB	BC	GB	
Vantage Point:			KP	RL	HB		
Vantage Point Counts	1						
	2						

Start time:	
Finish time:	

 # boat trailers at:

Session Start	Middle of Session	Session Finish

Tides and Moon

	Time	Level
Low tide	: am/pm	.
High tide	: am/pm	.
Moon phase		

Weather conditions

Sea state:	1	0.1–0.5	2	0.5–1.0
	3	1.0–2.5	4	2.5–4.0
Rain:	1	Nil	2	Light, continuous
	3	Light, scattered	4	Medium, scattered
Overhead:	1	Sunny, continuous	2	Mainly sunny
	3	Mainly cloudy	4	Cloudy, continuous
Wind speed	1	Nil	2	Light (1-10 knots)
	3	Medium (11-20 knots)	4	Strong (21+ knots)

Wind direction	N	NE	E	SE
	S	SW	W	NW
	Nil		Variable	

Boat Launches				Boat Retrievals			
Time	Time	Time	Time	Time	Time	Time	Time

Boat Trailers Removed off site (Y/N)				Boat Trailers Retrieved off site (Y/N)			

BCO/SPE/CRA Boat ramp survey Session #

INTERVIEW SHEET

All retrievals		
Intercept time	:	am/pm
Outcome	I R N O Z X	
Trip start time	:	am/pm
Trip finish time	:	am/pm
travelling / time not fishing	.	hrs:mins

For methods other than line, dive, or potting; record method and target species below and terminate interview

Continue If relevant			
# Fishers		#	Age group
# males			<15
# females			15 - 20
			21 - 30
Zone			31 - 40
Days fished in last year			41 - 50
			51 - 60
Marlborough Sounds Q. (1-4)			60 +

Main method			
Method			
Target species			
			Tick
# lines		Burley	
# hooks per line		Fishfinder	
# pots lifted		Soft Bait	
# divers			
# tanks used	.		

Main method Catch			
Species Code	# Retained	# Legal Released	# Not Legal Released

Secondary method			
Method			
Target species			
			Tick
# lines		Burley	
# hooks per line		Fishfinder	
# pots lifted		Soft Bait	
# divers			
# tanks used	.		

Secondary method Catch			
Species Code	# Retained	# Legal Released	# Not Legal Released

Measurements (any method)

BCO		BCO		SPE		SPE	
(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)

Measurements (any method)

CRA				CRA			
TW (mm)	Sex	Injury index	Wgt (g)	TW (mm)	Sex	Injury index	Wgt (g)

APPENDIX 3: Charter Operator Logbook (filled out by observers)

Charter Operator Logbook

Operator Number

Fill in a new column for each new trip, each new zone fished within a trip, and each method used (catch from each trip, zone, and method to be separated). Always enter the Date, Zone, Trip time, Methods used and Catch. Enter the sizes of retained catch where time permits.

TRIP		ZONE		METHOD		
Date				L	LL	N
				N	P	D
day	month	year				
Trip time	Start			am/pm		
	End			am/pm		
Total # of fishers	NZ		Overseas			
Effort	# Rods					
Line (L)	# Hooks per rod					
	Fishing time (hrs)					
Longline (LL)	# Hooks					
	Fishing time (hrs)					
Net (N)	Length (m)					
	Fishing time (hrs)					
Pots (P)	# pots					
	Pot time (hrs per pot)					
Diving (D)	# divers					
	Time (hrs per diver)					
Other (describe)						
	(hrs)					

Catch					
Species Code			# Retained	# Legal Released	# Not Legal Released

TRIP		ZONE		METHOD		
Date				L	LL	N
				N	P	D
day	month	year				
Trip time	Start			am/pm		
	End			am/pm		
Total # of fishers	NZ		Overseas			
Effort	# Rods					
Line (L)	# Hooks per rod					
	Fishing time (hrs)					
Longline (LL)	# Hooks					
	Fishing time (hrs)					
Net (N)	Length (m)					
	Fishing time (hrs)					
Pots (P)	# pots					
	Pot time (hrs per pot)					
Diving (D)	# divers					
	Time (hrs per diver)					
Other (describe)						
	(hrs)					

Catch					
Species Code			# Retained	# Legal Released	# Not Legal Released

Measure as many retained Blue Cod (BCO) and Sea Perch (SPE) as possible. Measure fish in cm or mm from the tip of the nose to the tail fork (or tail tip if no fork).

TRIP ONE SIZES

B C O Length (cm)	S P E Length (cm)

TRIP TWO SIZES

B C O Length (cm)	S P E Length (cm)

APPENDIX 4: Total effort equations

Estimation of total effort

The fishing effort (vessel hours) for sample day *m* in Kaikoura was estimated by the method of Jones & Robson (1991) as follows:

$$e_m = fT\sum_i^n \left[\left(\frac{1}{w_i} \right) \sum_j X_{ij} \right] \tag{1}$$

where T is the time taken to complete the bus route, (varied depending on weather, but generally between 9 and 11 hours), n is the number of boat ramps (6), w_i is the interviewer wait time at boat ramp i, X_{ij} is the time trailer j spends at boat ramp i during the sample session.

Fishing effort per sampling day was then corrected as described in the methods, for trailers that were parked off-site, for trips that started earlier in the day than sampling, and for the proportion of vessels that were relevant (that line fished for blue cod or sea perch).

The estimated variance $V(\bar{e}_k)$ within stratum k (k = 4; 2 locations x weekend/weekday) is calculated as follows (Pollock et al. 1994):

$$s_k^2 = \frac{1}{n_k - 1} \sum_{m=1}^{n_k} (e_{km} - \bar{e})^2 \tag{2}$$

where n_k is the sample size (days) for stratum k, e_{km} is the effort for stratum k on day m and $\bar{e}_k$ is the mean daily fishing effort (in hours and fishing trips) for stratum k.

The variance associated with the estimate of the mean, with finite population correction (Neter et al. 1988) is:

$$V(\bar{e}_k) = \frac{s_k^2}{n_k} \left(\frac{N_k - n_k}{N_k} \right) \tag{3}$$

where is N_k is the total number of days in stratum k.

The total effort for stratum k is estimated as:

$$\hat{E}_k = \frac{N_k}{n_k} \sum_{m=1}^{n_k} e_{km} \tag{4}$$

The variance associated with $\hat{E}_k$ is estimated by:

$$V(\hat{E}_k) = N_k^2 V(\bar{e}_k) \tag{5}$$

The standard error is calculated by the usual method:

$$SE(\hat{E}_k) = \sqrt{V(\hat{E}_k)} \tag{6}$$

The total effort is estimated by summing the effort for each strata as follows:

$$\hat{E} = \sum_{k=1}^{n} \hat{E}_k \tag{7}$$

where n is the number of strata.

Similarly, the variance of $\hat{E}$ is estimated as:

$$V(\hat{E}) = \sum_{k=1}^{n} V(\hat{E}_k) \tag{8}$$

The standard error of $\hat{E}$ is calculated by the usual method:

$$SE(\hat{E}) = \sqrt{V(\hat{E})} \tag{9}$$

APPENDIX 5: Length (cm)-weight (g) relationships for blue cod, sea perch, and rock lobster

Common name	Scientific name	Equation	Source for equation
Blue cod	*Parapercias colias*	$W=1.02\times10^{-2}L^{3.123}$	Blackwell (1997)
Sea perch	*Helicolenus percoides*	$W=7.767\times10^{-3}L^{3.219}$	Schofield & Livingston (1996)
Rock lobster			
Male		$W=0.128\times10^{-2}L^{3.222}$	N. Bentley (pers. comm.)
female		$W=0.896\times10^{-2}L^{2.638}$	

APPENDIX 6: Estimation of a tail width to weight relationship for rock lobster

Data collected on rock lobster tail widths and weights during the 2013–14 Kaikoura/Motunau survey were used to estimate a tail width to weight relationship. Sex, tail width, and weight were recorded for a total of 291 undamaged lobsters. An initial inspection of the data suggested several erroneous data points (Figure 6.1) where it appears that the sex was recorded incorrectly. Rather than attempt to correct errors, apparent outliers were removed. This was done on the basis of the ratio of weight to tail width assuming isometric scaling, ws3, where w is the weight in grams and s is the tail width in millimetres. Records were excluded where the ratio was outside of the range 0.0024–0.04 for males and 0.0015–0.0025 for females. These are arbitrary, but convenient, criteria for removing outliers that are more reproducible than "manually" removing outliers. After applying the criteria, records for 148 females and 130 males remained.

Parameters of the tail width to weight relationship,

$$w=a.sb$$

were estimated using a linear model,

$$\log(w)=\log(a)+b.\log(s)$$

Table 6.1 provides parameter estimates for each sex as well as those estimated by Breen & Kendrick (unpublished data) for the "NSN stock" (comprising CRA 1, 2, 3, 4, and 5) using a larger data set. Figure 6.2 shows the fitted relation and compares it to the relation predicted from the Breen & Kendrick parameter estimates. Note that for both sexes the relations estimated here have a higher slope and lower intercept than the estimates from Breen & Kendrick. Figure 6.3 shows this comparison on log space.

Table 6.1: Estimated parameters of the tail width to weight relationship from this study and from the Breen & Kendrick (unpublished data) study.

Sex	*a*	*b*
Males (this study)	0.00128	3.222
Males (Breen & Kendrick, unpub data)	0.00416	2.935
Females (this study)	0.00896	2.638
Females (Breen & Kendrick, unpub data)	0.013	2.545

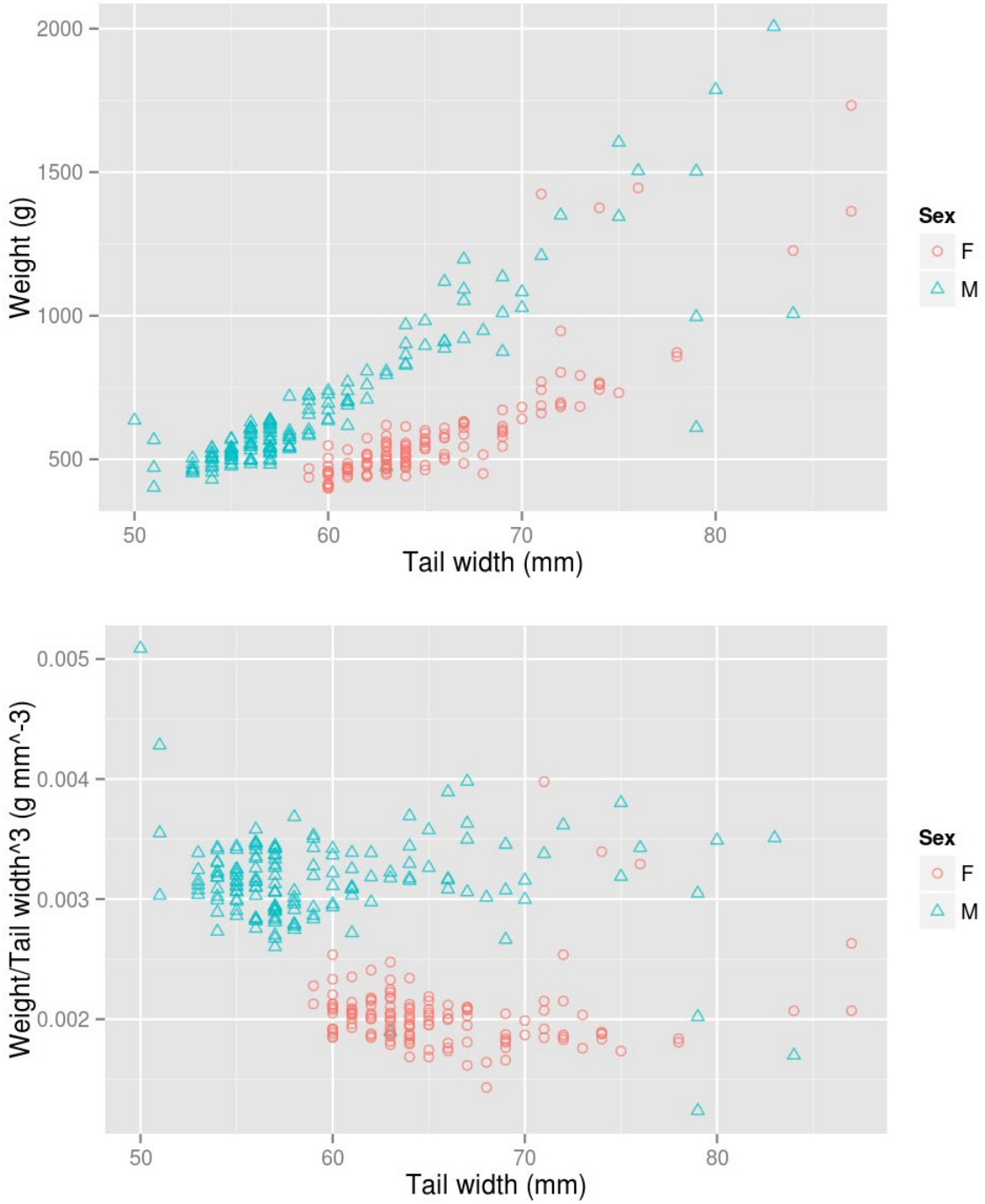

Figure 6.1: Plot of the available data (top) and the ratio used as a criterion to exclude apparent data errors (bottom).

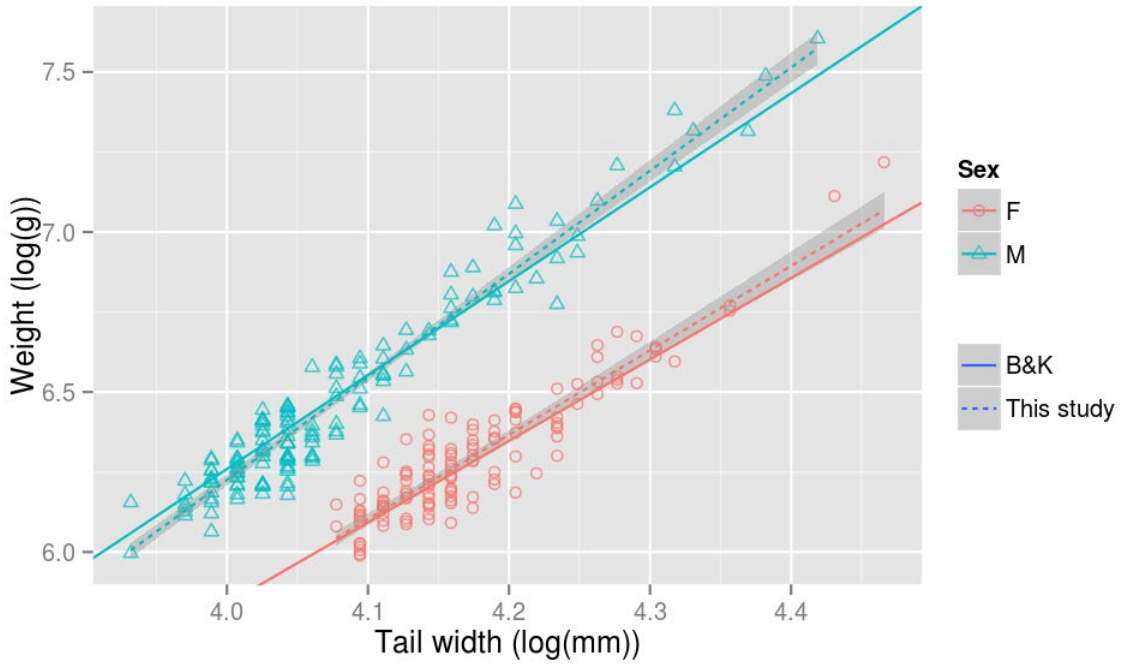

Figure 6.2: Plot of data and fitted linear model for each sex. Ninety five percent confidence intervals are shown for the fitted model. Also shown are the predicted weights using the coefficients estimated by Breen & Kendrick (unpublished data).

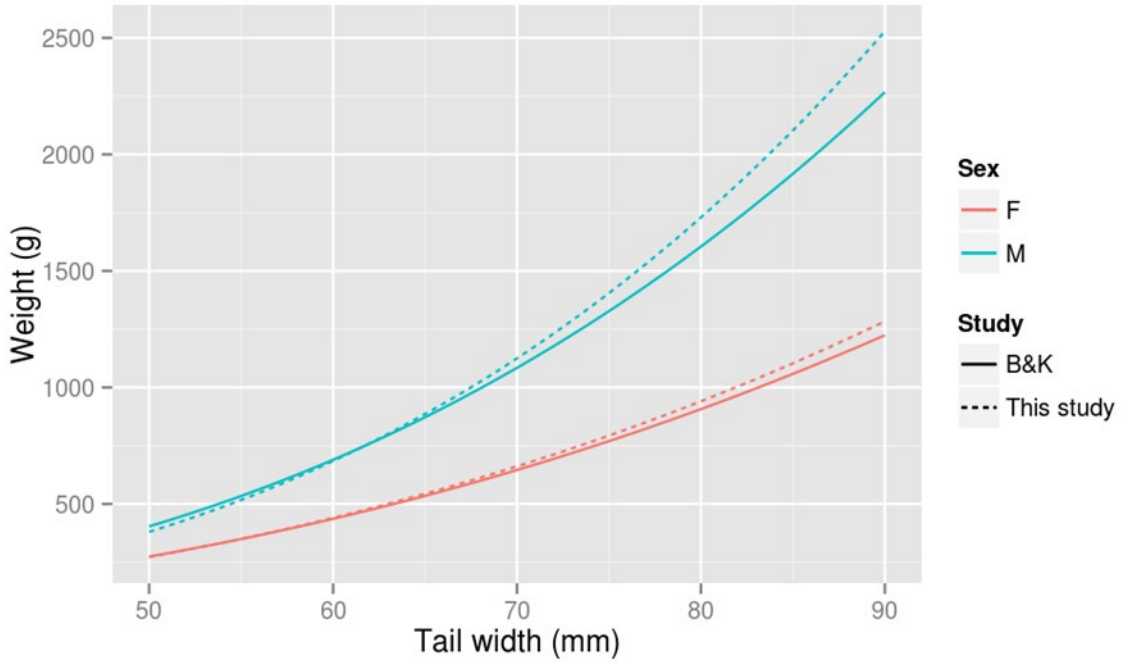

Figure 6.3: Comparison of fitted models in log space.