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Pāua harvest estimate by land-based amateur fishers—Kaikōura Marine Area in 2023

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This survey provided detailed information on the amateur harvest of blackfoot pāua (*Haliotis iris*) in the Kaikōura Marine Area. Estimates of total recreational fishing effort and data on the size and catch rate of pāua were collected using roving counts of fishers and interviews at land-based access points along 60 km of coastal highway.

Following a series of significant earthquakes in 2016, the commercial and recreational fisheries from Marfells Beach to the Conway River were closed to pāua harvest to allow for protection of the remaining pāua populations and associated habitats. The fishery reopened in December 2021 for a three month open season and the first amateur pāua harvest survey was initiated to monitor how the fishery responds to fishing pressure.

This report documents the second survey conducted to estimate the amateur harvest of pāua in the Kaikōura Marine Area and the first survey to provide weekly updates of harvest estimates. The emphasis of the survey was on estimating the amateur harvest of pāua during an open season in autumn from 15 April 2023 to 15 June 2023. The primary sampling unit in this survey was a random selection of days stratified by holiday/weekend days and weekdays. The opening weekend was defined as a separate temporal stratum, with Saturday and Sunday allocated as survey days to capture the anticipated surge in fishing effort and to refine survey implementation. A single access point survey in Oaro was also included in the on-site interviews for the first time. Data for harvest estimates for rock lobster (*Jasus edwardsii*), yellowfoot pāua (*Haliotis australis*), and kina (*Evechinus chloroticus*) were also collected and analysed.

Harvest methods were defined as hand gathering, where people wade or lie in the water to look for or feel under rocks for pāua which mainly occurs around low tide and snorkelling, swimming with a mask to gather pāua and target a range of species at high and low tide. Separate high and low tide survey sessions were conducted on survey days. Gathering pāua using SCUBA or other underwater breathing apparatus is not permitted.

There were four Māori customary fishing areas closed to pāua fishing in the Kaikōura Marine Area during the open season including the taiāpure around the Kaikōura Peninsula. The Hikurangi Marine Reserve covers two kilometres of rocky coast and is permanently closed to removal of all marine species.

The survey in areas open to pāua fishing in the Kaikōura Marine Area estimated a total of 6888 people were in the water and 26 170 pāua were kept. Based on length and weight data collected, the amateur harvest estimate of pāua at Oaro for the survey period was 32.6 kg (CV 0.49) and the combined survey area was 11.66 tonnes (CV 0.25).

[1] Blue Water Marine Research, New Zealand.
[2] Dragonfly Data Science, New Zealand.

1. INTRODUCTION

Blackfoot pāua (*Haliotis iris*) has traditionally supported significant customary, recreational, and commercial fisheries on shallow rocky reefs, especially in cooler waters around New Zealand. The Kaikōura Coastal Highway provides access to many kilometres of rocky shoreline and productive pāua habitat.

In November 2016, Kaikōura and the wider region experienced a series of significant earthquakes that caused large coastal uplift of up to 6 metres along 110 kilometres of coastline. This uplift led to extensive habitat modification and pāua were particularly affected with very high mortality at all life stages and loss of critical intertidal and sub-tidal habitats. The amount of the pāua fishery area lost to the uplift has been estimated to be 20% of previously fished areas (Neubauer 2017).

To promote a rebuild and protect the surviving pāua populations and associated habitats, as well as other shellfish and seaweed resources, an emergency closure of the fishery was introduced between Cape Campbell/Marfells Beach and the Conway River (Figure 1). The closure remained in place for five years under section 11 of the Fisheries Act 1996 and did not apply to rock lobster (*Jasus edwardsii*), scampi (*Metanephrops challenger*), kina (*Evechinus chloroticus*), and octopus fishing, or to customary fishing.

Surveys of the impacted areas indicated large scale recovery of pāua populations and sustained increases in pāua biomass supporting a reopening of the fishery (McCowan & Neubauer 2021). The fishery reopened for three months in December 2021 and the first survey of recreational pāua harvest was commissioned for the duration of the season to allow for "a careful approach by opening the fishery for a three-month period while also ensuring it can be monitored closely to understand how the pāua responds to fishing". The survey estimated a total amateur pāua harvest of 42 t (CV 17.5%), higher than historical National Panel Survey estimates (Holdsworth 2022).

Feedback from tangata whenua, the Kaikōura Marine Guardians, and the public regarding the 2023 fishing season, supported a reopening of the fishery during a quieter time of year. The pāua fishery reopened for a limited two-month open season on 15 April and finished on 15 June. In addition, the daily bag limit for blackfoot pāua was reduced from five to three per person.

The survey of amateur pāua harvest estimate was implemented for a second time, this time providing a rolling weekly estimate reported to a reference group of stakeholders including Fisheries New Zealand representatives, Te Rūnanga o Kaikōura, and Kaikōura Marine Guardians. This was to allow for the consideration of in-season management changes if required.

There are limited historical data on the size of the amateur pāua harvest in the Kaikōura region. The first telephone-diary survey estimated the amateur harvest of pāua in PAU 3 to be between 35 and 60 t (Teirney et al. 1997). However, subsequent surveys identified a methodological error in the survey method and these estimates are no longer considered reliable (Fisheries New Zealand 2022). The National Panel Survey (NPS) is a nationwide off-site survey of a random population proportionate sample of resident marine fishers, and a sample of the public screened as non-fishers, who reported their actual fishing activity over the fishing year during regular phone interviews (Wynne-Jones et al. 2014, Wynne-Jones et al. 2019). The 2011–12 NPS estimated that 10.3 tonnes (CV 0.31) of recreational pāua harvest came from the area between the Clarence River and the Conway River. There were 21 panellists reporting pāua from this area, but that year the survey probably underestimated harvest because it did not recruit any panellists resident in the Kaikōura region (by random chance). The survey estimated the proportion of shore-based harvest in the Kaikōura area was over 90% prior to the earthquake. The pāua fishery on the Kaikōura coast was closed during the 2017–18 National Panel Survey and the results of the 2022–23 National Panel Survey will be available in 2024.

The overall objective of Fisheries New Zealand research project SEA2022-06 was to undertake a survey to estimate the pāua recreational harvest in the Kaikōura region.

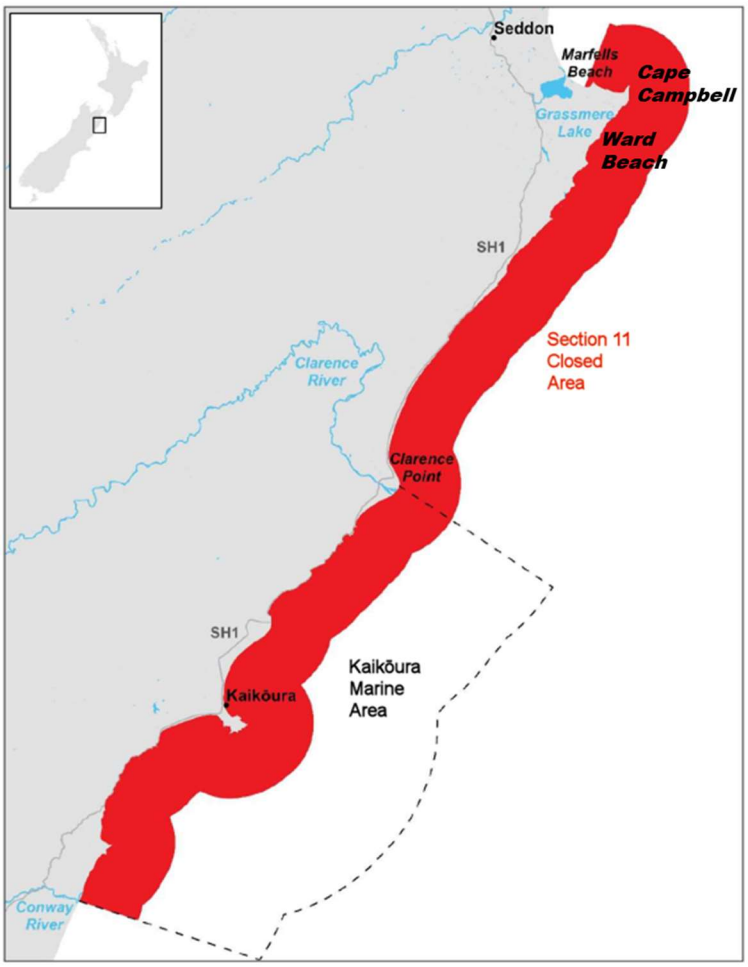

Figure 1: The location of the Kaikōura Marine Area within the area closed to shellfish and seaweed harvest following the November 2016 earthquakes (red).

2. METHODS

2.1 Kaikōura Marine Area survey

The Kaikōura Marine Area (KMA) extends from Clarence Point, south to Conway River. Large sections of the coastline is rocky shore and shallow reefs where pāua are likely to be found. Within this area the Hikurangi Marine Reserve includes a two kilometre coastal boundary at Raramai and there are five customary management areas, four of which were closed to pāua harvest during the open season. The Oaro-Haumuri Taiāpure reopened for the duration of the 2023 season with a daily bag limit of 2 pāua per person and a minimum legal size of 135 mm.

A survey design for PAU 3, including a survey approach for the Kaikōura area, was proposed in 2016 by NIWA but not implemented (Hartill 2023). The 2022–23 survey design was adapted from the previous survey in 2021–22 developed by Blue Water Marine Research (Holdsworth 2022). The survey used a roving-access survey approach with an instantaneous count of fishers to estimate fishing effort and separate on-site interviews of fishers when they have finished fishing to estimate the catch rate per hour within each spatial and temporal stratum (Holdsworth 2021).

An interviewer was stationed at the main access point at Oaro for 4-hour survey sessions around low tide on the same stratified random set of days as the Kaikōura survey. Total harvest for this location was calculated using direct expansion as described for the stationary interview sites in the 2021–22 survey (Holdsworth 2022).

Access point surveys have a number of advantages over off-site surveys. They involve direct observation of retained catch and interviews to collect information on fishing effort immediately after fishing has occurred, minimising recall bias (Pollock et al. 1994, Connelly & Brown 2011).

2.2 Temporal stratification

This survey covered the open season for recreational pāua harvesting from 15 April 2023 to 15 June 2023. Survey days are the primary sampling units. The first two days of the open season were sampled to enable project initiation and training and to capture any initial surge in fishing effort. The remaining 60 days of the season were chosen at random with equal probability without replacement. Two consecutive survey days were allowed, but three consecutive days were not. Fishing effort and harvest are assumed to be the same on average to survey days on weekends and holidays. More frequent sampling when fishing effort is higher results in more precise estimates of catch and effort when survey day harvest is scaled up to all days in the stratum (Pollock et al. 1994). For the amateur pāua fishery, the hours either side of low tide provide easier access and are likely to attract higher fishing effort.

The primary temporal sampling frame for the Kaikōura pāua survey is based on two day-type strata (weekend/public holiday and weekday) and two tidal strata (low tide and mid to high tide). In addition, a separate stratum was created for the first weekend after opening. The first week of the season was a school holiday. Monday to Friday of the school holidays were included in the weekday stratum. There were two public holidays within the season, Anzac Day and King's Birthday. The survey design also took account of the requirement to provide in-season updates of pāua harvest. The sampling intensity in the 2023 survey was higher than in the previous survey of amateur pāua harvest to help provide reasonable precision in the weekly running total harvest estimates. There were 24 survey days consisting of the 2 on the opening weekend, 11 days across weekends and public holidays, and 11 weekdays (Table 1).

There were two tidal strata per survey day, a low tide stratum of up to four hours consisting of two hours each side of the predicted low tide for Kaikōura, and a mid/high tide stratum of up to eight hours to cover the full tidal cycle. The times between sunrise and sunset were used to define the survey day length, which were less than 12 hours during the 2023 autumn open season. Within each tidal stratum there was a randomised start time and location for the roving count of people in the water and parked vehicles. The coverage of early morning and evening hours in tidal strata varied depending on the low tide times on the randomly selected survey to fit between sunrise and sunset.

Table 1: Temporal sampling design for the recreational harvest survey starting on 15 April 2023.

Season	Day type	Days in stratum	Surveyed days	Sampling intensity
	First weekend	2	2	1.00
Autumn	Weekend/holiday	18	11	0.61
	Weekday	42	11	0.26
	Total	62	24	0.39

2.3 Spatial stratification

Sixty-kilometres of coastline in the Kaikōura Marine Area was in the survey area, including areas that were not recognised as favourable pāua habitat. Two spatial strata were used to ensure that the roving count of fishers was completed within a relatively short time frame within each stratum. The northern stratum from Clarence River to the Hāpuku River is about 20 km by road running alongside rocky coastline with shallow reef habitats. The southern stratum began south of the Kaikōura Peninsula and includes the two kilometre coastal boundary of the Hikurangi Marine Reserve. The main survey area within the southern stratum is about 15 km by road from Peketā to Oaro and has large sections of gravel beach that do not have suitable pāua habitat (Figure 2). The Kaikōura Peninsula Taiāpure was closed to pāua fishing and was not included in the survey. A third survey stratum was a single access point at

Oaro. Fishers can access shallow reefs south of the Oaro River and the Oaro Mātaitai which was closed to recreational fishing (Figure 3). There is no road access or suitable vantage point that would have allowed this area to be included in the main roving survey.

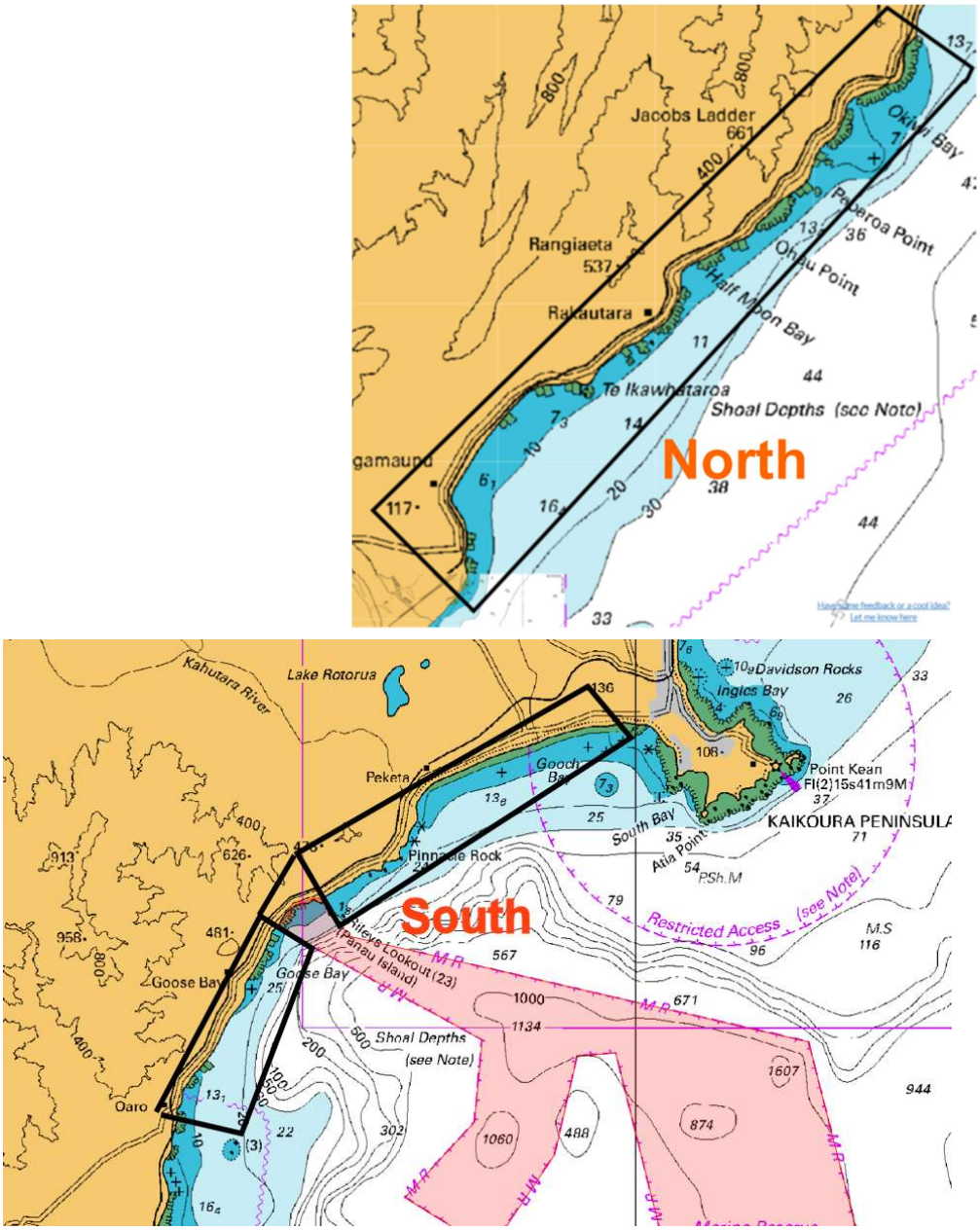

Figure 2: The location of the spatial strata for the Kaikōura pāua roving survey in 2023. The Kaikōura Peninsula was not surveyed because pāua gathering was prohibited there.

Figure 3: The location of the Oaro Mātaitai (red) which was closed to recreational and commercial fishing and the reefs to the south which are accessed by a track along the coast which was closed to vehicles in 2023.

2.4 Survey approach

Each spatial stratum was divided into sections, using the same survey section definitions as the 2021–22 survey. The northern stratum was divided into 11 sections and the southern stratum was divided into 10 sections to support analysis and description of catch distribution along the coast (Holdsworth 2022). There were two 3-hour survey sessions per spatial stratum per survey day with a random start time selected within the low and high tide strata.

The roving survey of fishing effort recorded a semi-instantaneous count of pāua gatherers and people in the water with them by driving the coastal highway and stopping at vantage points. The start time of the 60-minute roving survey, start location, and direction of travel were selected at random within each spatial and tidal stratum. A clockwise travel direction was selected for the south route on long weekends, which were likely to have the most traffic, to avoid having to cross traffic when pulling into carparks. The roving counts required two survey clerks, one driving and the other spotting pāua gatherers in the water or parked vehicles. These areas would be searched using binoculars. This provided a point-in-time estimate of total effort for people that may claim pāua catch. In addition, parked vehicles were counted at well-known pāua gathering locations. These counts may be used in future to support pāua fishing effort estimates. Data collected during the roving survey were recorded using the app 'Fastfield' on a tablet and was uploaded to the server at the close of each roving session.

For the on-site fisher interviews, the interviewers for the north and south spatial strata were required to travel between access points within a pre-determined 3-hour time frame. Interviewers had the freedom

to select the sections where they would conduct interviews to fit around the time taken to make the counts of people in the water. Interviewers would intercept groups at the end of their fishing trip as they returned to the carpark and collect information on the time of the interview; the number of people who went into the water; pāua retained catch per person; time in the water per person; pāua released per person; method used (hand gathering without a mask or snorkelling); individual shell length and weights of pāua; and place of residence. Interviewers were also asked to record the number of other species caught including yellowfoot pāua, kina, and the sex and size information of rock lobster harvested. The voluntary catch recording app 'Mainland Catch' added pāua to the list of species that could be reported. Fishers were asked whether they would be recording today's catch on this app. The survey focus is amateur harvest—customary non-commercial harvest has its own recording system and was not recorded by interviewers.

2.5 Pāua length to weight conversion

Pāua growth rates and shell shape vary by location and habitat. In 2021 data on individual pāua lengths and weights were obtained from post-earthquake monitoring in the KMA (Tom McCowan pers. comm.). Interviewers in 2023 used waterproof electronic scales to weigh pāua to the nearest gram and ZebraTech digital measures on loan from the Pāua Industry Council to accurately measure them in millimetres rounded down. These data were used, in combination with previous data used in 2022, to revise the length-weight relationship for the Kaikōura recreational pāua fishery.

The updated length-weight relationship was estimated using a Bayesian regression of log weight and log of length, using sampling area as a random effect. The areas were north, south and Oaro strata for the current survey, and sampling location as noted in the previously used dataset. Models were run for 2000 Markov chain Monte Carlo (MCMC) iterations across 4 independent chains. Convergence was checked visually and using the Rhat criterion (Vehtari et al. 2019). To avoid bias in parameter estimates due to running the model on a log scale, mean and standard deviation of length-weight parameters were calculated after back-transforming individual MCMC samples.

Note that pāua take time to drain once removed from the water. This draining reduces weight so fishers were asked how long their catch had been out of the water prior to being weighed in the interview.

2.6 Calculation of harvest estimates

The instantaneous roving count of people in the water at pāua fishing locations provides a point-in-time estimate of fishing effort in that stratum and the separate interviews at the completion of the fishing trip provides the mean catch rate for that stratum.

An estimate of the total fishing effort, $\hat{e}$, taking place within a spatial stratum within a tidal stratum j on a given survey day i is

$$\hat{e}_{ij} = I_{ij} \times T_j \qquad (1)$$

where Iij is the randomly timed 'instantaneous' count of gatherers per hour made during the tidal stratum j on the survey day and Tj the length of that tidal stratum expressed in hours.

These estimates can be combined and scaled up to provide an estimate of the total effort taking place during the tidal phase j across all days occurring within each day type stratum k, which is

$$\hat{E}_{kj} = \frac{\sum_i e_{ikj}}{\pi_k} \qquad (2)$$

where π_k is the proportion of days surveyed within each day type stratum.

An estimate of the arithmetic average catch rate for a given day type/tidal stratum *kj* is made from data collected during interviews with gatherers when they have finished harvesting,

$$\hat{R}_{kj} = \frac{\sum_{t=1}^{n} h_{kjt}}{\sum_{t=1}^{n} L_{kjt}} \qquad (3)$$

where h_t is the harvest and L_t is the length of trip t expressed in hours and n is the number of trips investigated (Pollock et al. 1994).

An estimate of the harvest occurring during a day type/tidal stratum *kj* over the survey period is therefore,

$$\hat{H}_{kj} = \hat{E}_{kj} \times \hat{R}_{kj} \qquad (4)$$

Harvest estimates for pāua and rock lobster can be expressed in terms of numbers taken or weight. Pāua catch weights were calculated from the newly estimated length-weight relationship.

For this survey, all harvest estimate analyses were coded in R, which allowed for efficient weekly updates of survey estimates. A nested bootstrap was used to estimate the coefficient of variation of total catch. The bootstrap resampled:

1. Days within survey strata (survey route, day type [first weekend/weekend/weekday])
2. Trips within days
3. Pāua numbers at size within trips.

Rock lobster tail width to weight conversions were made using the equations by sex given by the CRA 5 plenary report (Fisheries New Zealand 2021).

2.7 Oaro survey

The Oaro survey area is located south of the main Kaikōura survey stratum and was also closed following the earthquakes. The beach has limited access through the village and across a railway. Vehicle access has been blocked and most effort by fishers is on foot. There are two customary management plans in place in Oaro, the Oaro-Haumuri Taiāpure which reopened for the 2023 season and the Oaro Mātaitai which remained closed to all pāua harvest. Survey sessions at this site were four hours long around low tide on the same stratified random set of days as the Kaikōura survey. It was anticipated that this was when most of the fishing effort for pāua occurred, because access was along the coast and pāua were on subtidal reefs fished by divers rather than wading. Survey clerks followed the same interview process as the main Kaikōura survey; however, interviewers were not required to do a count of people in the water or parked vehicles.

Total harvest was calculated using direct expansion of the sum of observed catch on survey days by day type multiplied by the sampling fraction for each day type stratum.

3. RESULTS

All survey sessions on the 24 selected survey days were completed. Across the three spatial strata there were 275 groups of fishers/gatherers interviewed with a total of 563 people. The interviewers recorded 1246 retained pāua, 73 yellowfoot pāua, 67 rock lobster, and 157 kina, with pāua harvest recorded on every survey day (Table 2).

Table 2: Number of survey interviews and number of the primary species landed by spatial strata.

Survey area	Groups interviewed & fishing	Individual fishers interviewed	Landed pāua in interviews	Yellowfoot pāua in interviews	Rock lobster in interviews	Kina in interviews
North	103	227	561	32	4	7
South	162	319	647	41	57	150
Oaro	10	17	32		6	
Total	275	563	1 240	73	67	157

3.1 Length-weight relationship

The model fitted the length-weight data well, for individual areas and in aggregate (Figures 4, 5, A1), only the length-weight relationship at the peninsula appeared slightly different from the overall relationship found for the Kaikōura region. The estimated relationship is given by:

$$\text{Weight} = 3.67984\text{e-}05 \times \text{Length}^{3.296555}$$

where weight is in grams and length in millimetres.

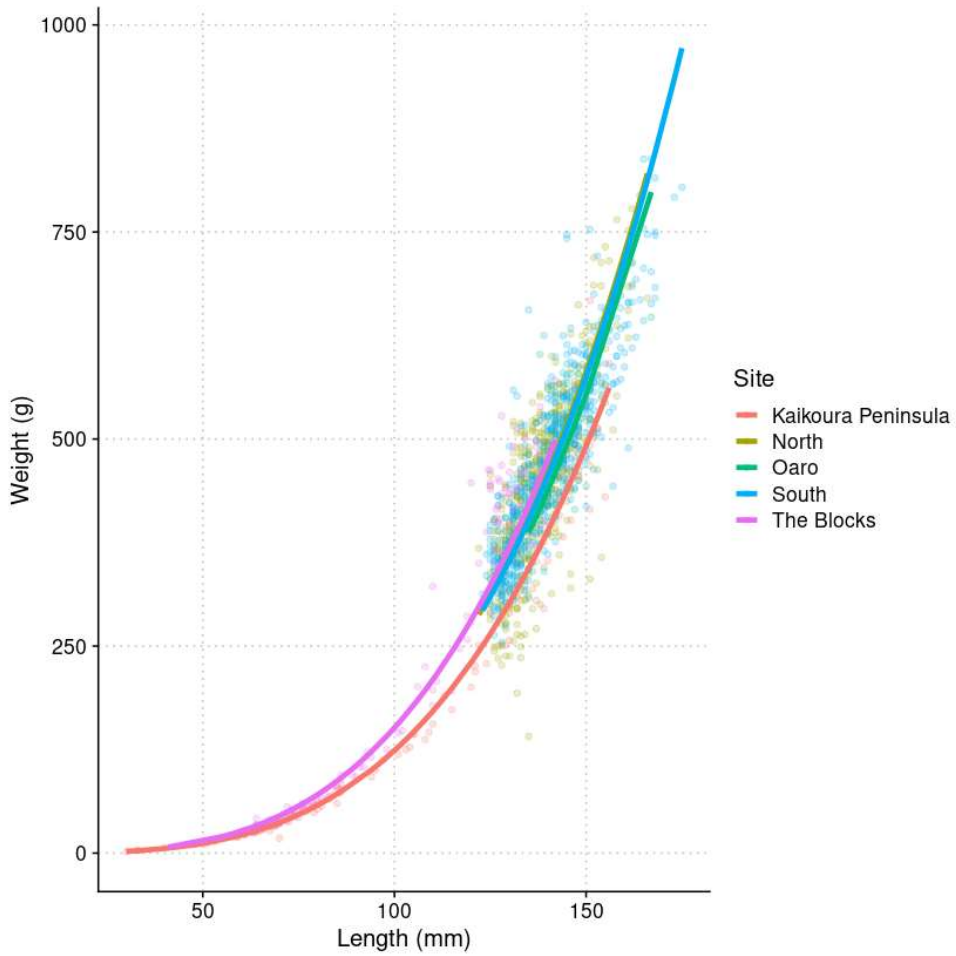

Figure 4: Pāua length and weight data by area and corresponding length-weight regression estimate.

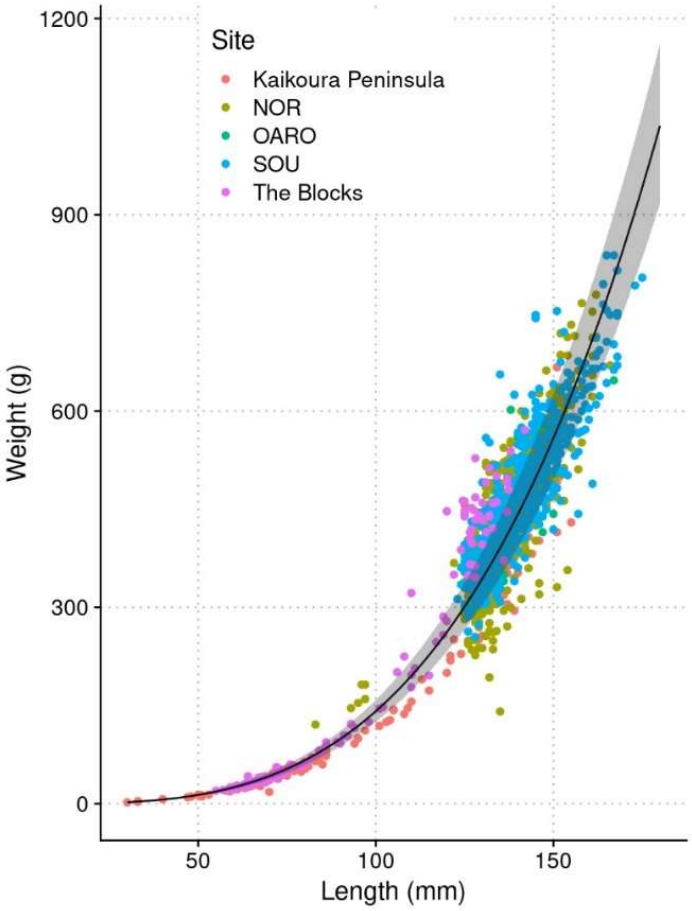

Figure 5: Pāua length and weight data used to calulate harvest weights. The minimum legal size was 125 mm in the recreational fishery.

3.2 Kaikōura Marine Area

Across the two roving survey strata in the Kaikōura Marine Area (KMA), the two survey days with the lowest number of pāua intercepted and most affected by poor weather and sea conditions were 15 May and 21 May 2023. The two days with the highest overall catch were 23 April and 3 June; both were on the weekend of a public holiday. As a result of the open season being held in autumn, weather and swell conditions were variable.

Interviewers recorded the time each interview started and the survey day was mostly spread from 0700 hours to 1700 hours. In theory this is the period with equal probability of fishers being counted or interviewed. Most interviews took place from 1000 hours to 1600 hours, with few interviews at the beginning and the end of the day (Figure 6).

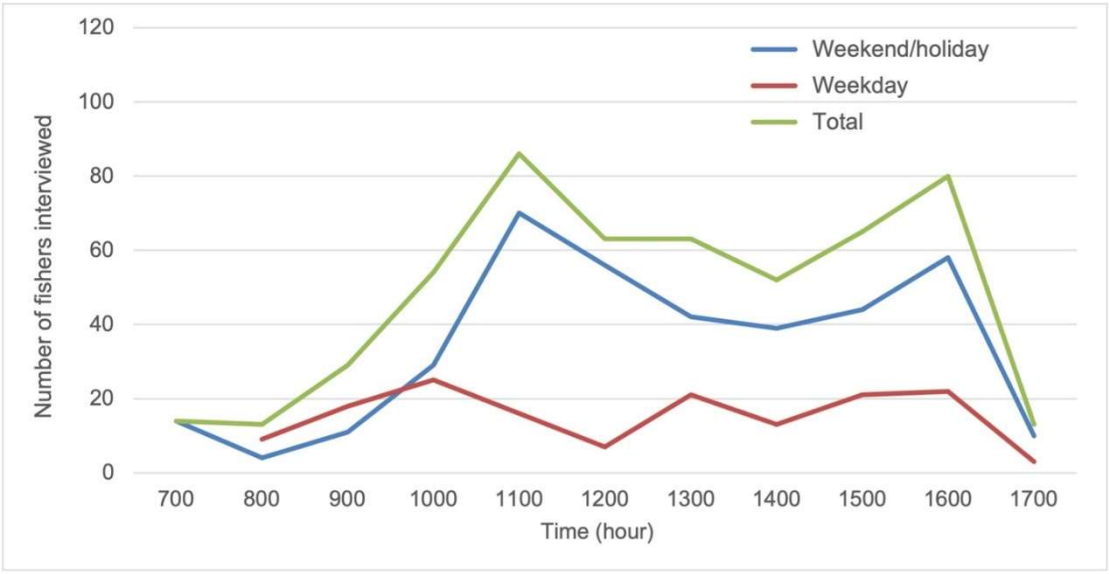

Figure 6: The number of pāua gatherers interviewed by hour from the Kaikōura Marine Area.

The number of fishers interviewed was highest on 3 June, the King's Birthday long weekend, followed by the Friday and Sunday prior to Anzac Day (Figure 7).

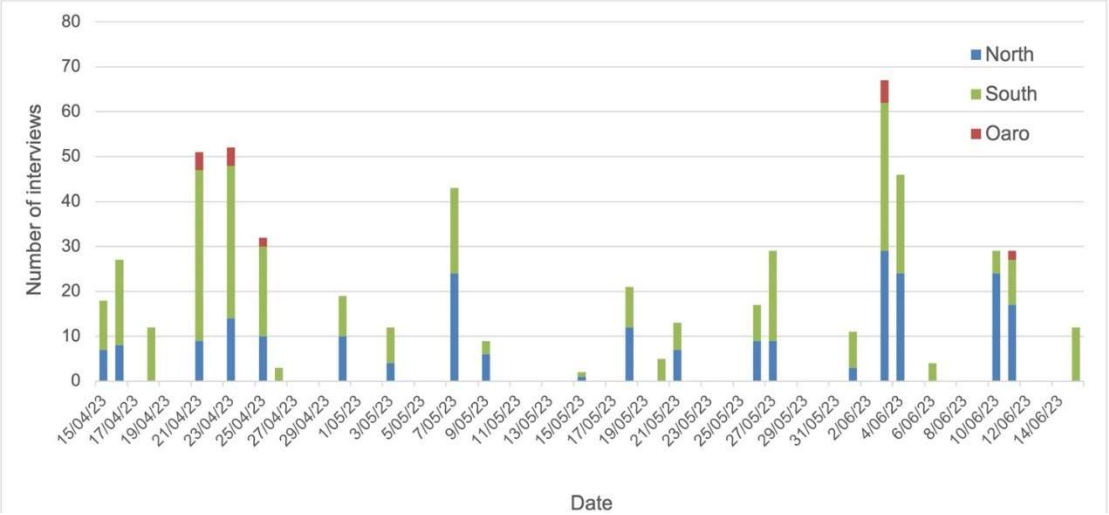

Figure 7: The number of pāua gatherers interviewed by survey day and spatial stratum.

Most fishers interviewed who were targeting pāua caught and kept the daily bag limit of three pāua (75%) and a further 11% kept no pāua. Some care is needed when interpreting catch per fisher because some groups combined their catch and there was no easy way of attributing pāua to a particular fisher. The other 14% of interviews recorded individual bags of one or two pāua.

Interviews recorded fishing methods as hand gathering, where people wade or lie in the water to look for or feel under rocks for pāua, or snorkelling using a mask to gather pāua or rock lobster or to spearfish. In the low tide stratum 16% of time in the water was recorded as hand gathering for 15% of landed pāua weight. In the high tide stratum 98% of time in the water was recorded as snorkelling for 99% of landed pāua weight.

Pāua shell lengths were measured to the millimetre rounded down and cooperation from fishers was generally very good with 97% of pāua measured from the number recorded in interviews and less than 1% that were measured as undersized, which were mostly returned to the sea. The length distribution

for the north route and south route was similar, with slightly more pāua lengths between 133 mm and 142 mm in the north and between 143 mm and 170 mm in the south (Figure 8, Table A1). The mean pāua shell lengths for the north survey area were 138.6 mm (sd 8.18) and 140.8 mm (sd 10.12) in the south. When plotted as a cumulative proportion the lines diverge at 133 mm and stay separated across the remaining size classes (Figure 9).

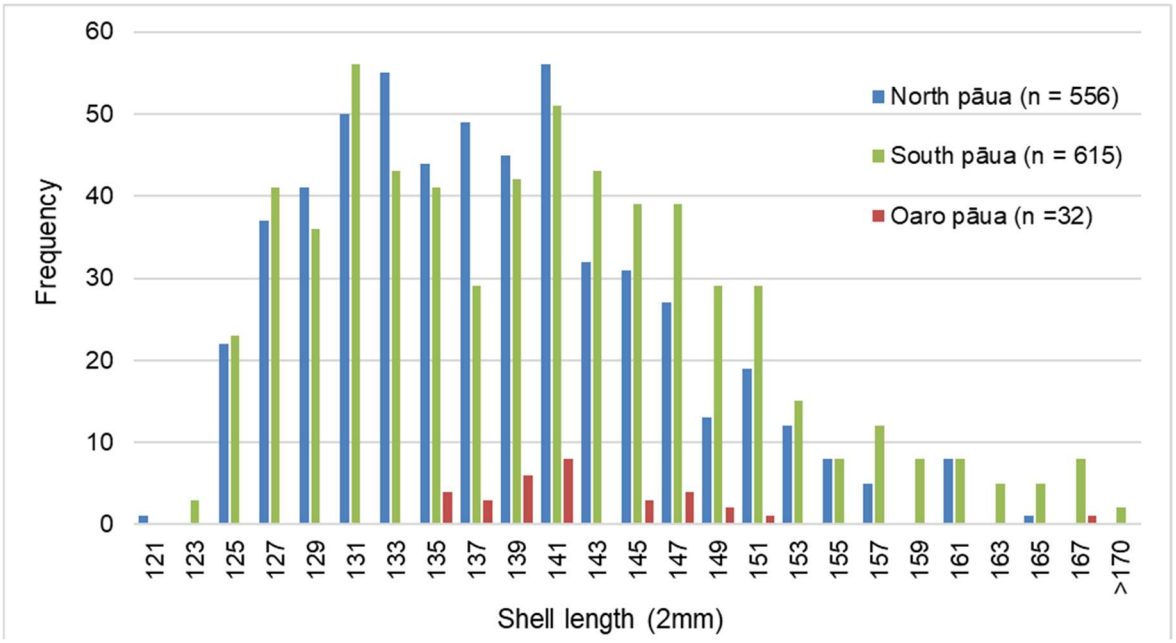

Figure 8: Shell length frequency distribution of pāua measured by survey route in the Kaikōura Marine Area.

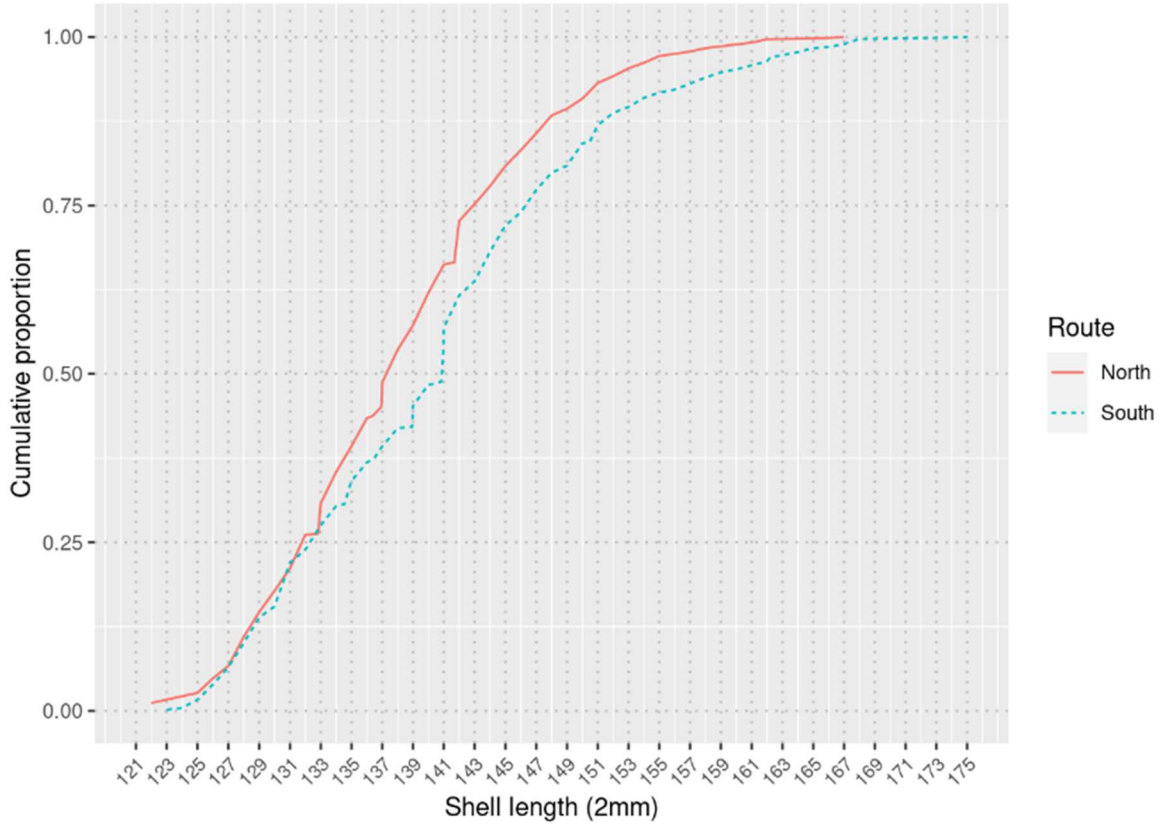

Figure 9: Cumulative proportion of pāua shell length by survey route in the Kaikōura Marine Area.

Overall the survey estimated 11.66 t (CV 0.25) of pāua harvested from the north and south strata over the two months by recreational fishers (Table 3). The highest weekly catch estimate was 2.74 t (CV 0.22) during the first week.

Table 3: Cumulative pāua harvest weight, total number of pāua harvested, and total hours of fishing effort estimated by week within the main survey strata in Kaikōura Marine Area.

Week	Total pāua harvest (t)	CV	Number of pāua (1000s)	Effort hours (1000s)
1 Saturday 15 April	2.74	0.22	6.39	1.65
2	4.54	0.21	10.25	3.05
3	6.10	0.29	13.74	3.96
4	7.56	0.32	16.73	4.70
5	8.48	0.27	18.39	5.40
6	8.48	0.30	18.65	5.43
7	9.37	0.29	20.74	5.85
8	10.94	0.26	24.41	6.74
9 Thursday 15 June	11.66	0.25	26.17	6.89

An important component of the pāua harvest estimate is the landed catch per hour which is based on fisher estimates of the time they spent in the water. In 2021, the Marine Amateur Fisheries Working Group recommended some dedicated survey effort to collect data on the actual time fishers spent in the water and their estimated time when interviewed. Paired data for 49 fishers showed that individuals within groups tended to enter and exit the water at the same time and their time estimates tended to be rounded (e.g., 20, 30, 40 minutes). Quite large underestimates and overestimates were made by fishers, especially when time in the water was more than 40 minutes. However, the average difference was small, 1.3 minutes (sd 24.23). No significant bias in fisher estimated time was found and no adjustment to landed catch per hour was made (Holdsworth 2022). This survey component was not repeated in 2023.

3.3 Oaro survey results

The coast south of Oaro has no road access and was not included in the 2021–22 survey. There was some concern that a large number of pāua were taken from that area and not accounted for. Four wheel drive vehicles and motorbikes were used to travel along the shore to areas with shallow reefs.

In 2023, NZ Rail had blocked off the track that led to the beach and the gate to the rail crossing was locked. The Oaro Mātaitai was closed to recreational fishers and the Oaro-Haumuri Taiāpure south of there had a lower daily bag limit of two per person and a minimum legal size of 135 mm, larger than the rest of the KMA. A local resident was contracted to survey for 4 hours around low tide per survey day when most fishing effort was likely to occur. He was also able to note the level of effort on non-survey days. There was very little. From 96 survey hours there were 17 fishers interviewed, mostly locals, and 32 pāua recorded. Scaled up to all survey days, the harvest estimate for south of Oaro was 32.6 kg (CV 0.49).

3.4 Pāua caught and released

Fishers were asked how many pāua they removed from the rocks and released. There were 477 pāua released in the Kaikōura Marine Area recorded in survey interviews. The total estimate scaled to all fishers for all days in the open season was 9506 (CV 1.02) pāua released. This is 27% of the catch by number but not by weight, because most pāua released would have been undersized or just over the

legal size. Sixty-three percent of fishers said they did not remove any pāua from rocks that they did not keep; a summary of the numbers released per fisher is provided in Figure 10.

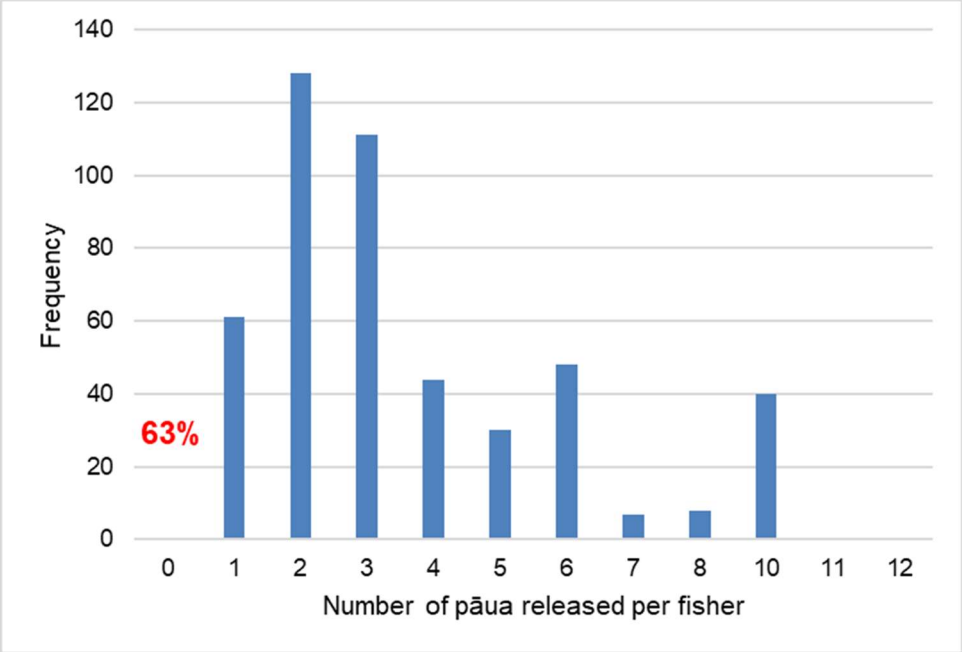

Figure 10: The number of pāua released per fisher from interviews in the Kaikōura Marine Area.

3.5 Spatial distribution of effort

The survey design divided the survey routes into sections, 11 in the north and 10 in the south, to help answer questions about the distribution of amateur pāua catch and effort on the Kaikōura coast. The independent nature of the count of people in the water and survey interviews meant that estimates of catch per hour and people per hour did not always align within all the sections. Estimating harvest weights for all 62 days by section was problematic. Estimates of the number of people in the water over all days show that effort was spread relatively evenly across the northern route, except in two areas with less effort (Figure 11). Significant highway reconstruction was needed along parts of the north route that now prevents access to the shore and water in several sections. The relatively sheltered central sections of the south route, either side of the Hikurangi Marine Reserve, had the most fishing effort across all the survey areas.

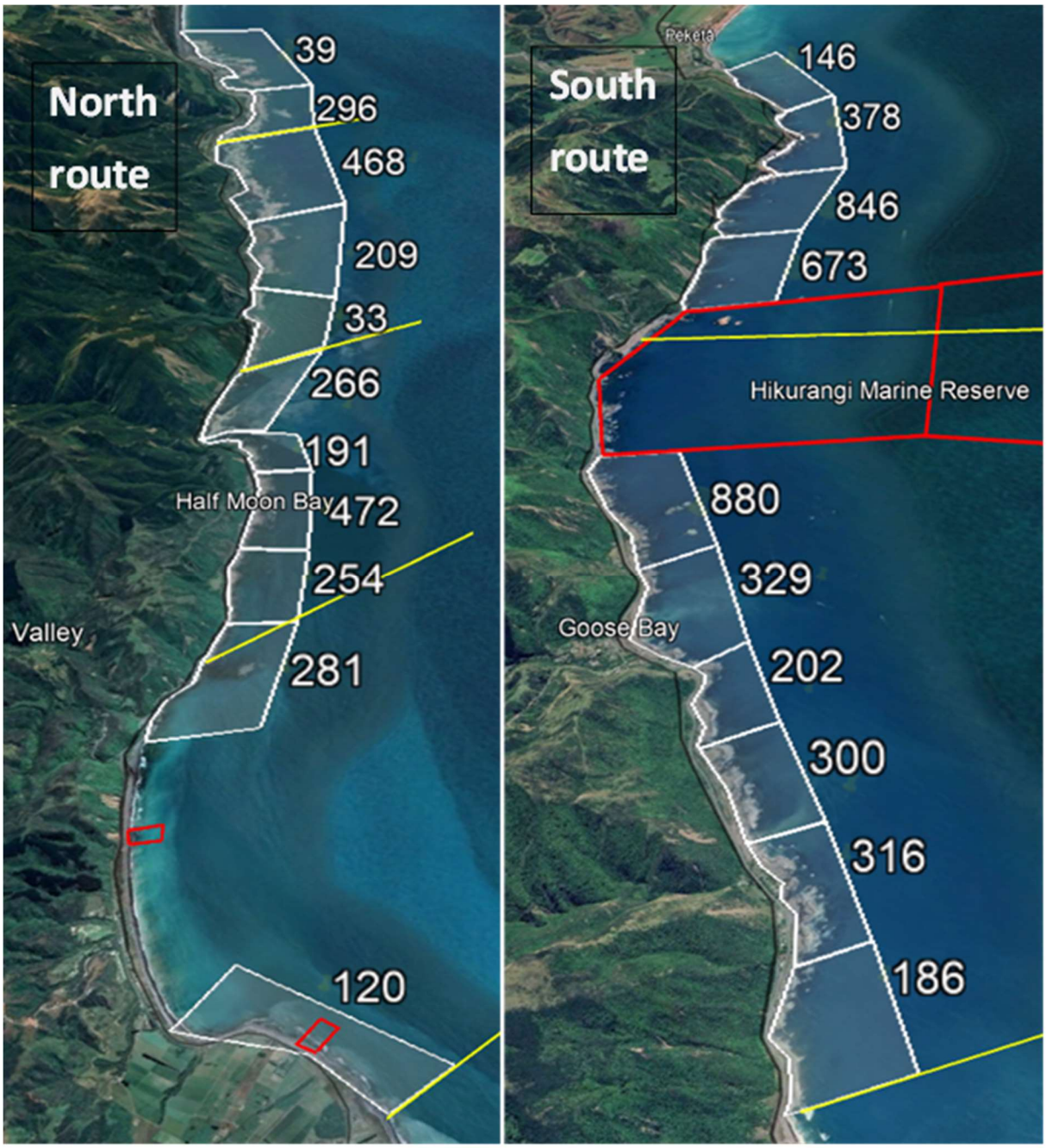

Figure 11: Estimated number of people in the water for all 62 survey days by survey sections.

3.6 Harvest estimates for other species

There were 67 rock lobsters retained by land-based fishers recorded by interviewers for the combined Kaikōura survey area. Harvest estimates have been calculated, although the data are quite sparse. Six rock lobsters were recorded at Oaro on survey days. The total estimate of rock lobster harvest in this survey was 1584 (CV 0.93) for the combined Kaikōura survey area (Table 4).

Table 4: Estimated total harvest of rock lobster, kina, and yellowfoot pāua in Kaikōura survey area.

Survey area	Rock lobster harvest numbers	CV	Kina harvest numbers	CV	Yellowfoot pāua harvest numbers	CV
North	432		100			
South	1 129		2 958			
Oaro	23		0			
Total	1 584	0.93	3 058	1.02	1 140	0.61

There were 73 yellowfoot pāua kept by hand gatherers and divers and recorded during interviews in the main survey area. No kina were recorded in the Oaro survey. No size or weight data were collected. Expanded harvest numbers for kina and yellowfoot pāua are provided in Table 4.

3.7 Mainland Catch app reporting

Fish Mainland (with support from the Ministry for Primary Industries through SFFF) have developed an app that recreational fishers can use to record their catch for a range of popular species in the South Island. There was an opportunity to gauge the participation rates of fishers during the on-site survey in 2023. On the opening of the pāua harvest season, pāua had not been added to the app and people were not aware that it was available. A question was added to the interview form and interviewers asked whether each fisher was going to report today's catch on the Mainland Catch app. The results in Table 5 highlight the difference between interviewers who helped explain what the app was and how to download it vs. interviewers who often did not ask the question or record the response. Of the fishers that had pāua catch and who responded to the question, 130 (45%) said they would use the app.

Table 5: The number of fishers and landed catch for people interviewed and targeting pāua by survey area.

	Will use Mainland Catch app					
Number of fishers targeting pāua	Yes	No	Yes (no catch)	No (no catch)	Blank (not asked or recorded)	Total
North	5	41		18	157	221
South	125	99	4	40	15	283
Oaro		16				16
Total	130	156	4	58	172	520
Proportion of fishers	0.25	0.30	0.01	0.11	0.33	
Number of landed pāua	370	395				

4. DISCUSSION

The pāua fishery is of high value to all fishing sectors and Kaikōura is a highly accessible, valued region for amateur fishers. The roving-access survey with an instantaneous count of fishers provided an estimate of fishing effort and separate on-site interviews of fishers to estimate the catch rate per hour based on accurate pāua length and weight information and fisher estimates of the time they spent in the water. The way these data were collected was altered for this year's roving survey. Having a pair of interviews for each route undertaking fisher counts, recorded on tablets with accurate times and locations, and separate times to interview fishers returned to shore or their vehicles worked well. The use of ZebraTech electronic measures and electronic scales in the field was also easier with two people working together.

This was the second broad-scale survey in Kaikōura and a relatively high proportion of available days were surveyed because the season was open for a short period and there was a risk that weather

conditions would adversely affect several of the randomly selected days. All allocated days were surveyed; however, fishing effort was highly variable due to changeable autumn weather conditions. Peaks of fishing effort occurred on and around public holidays, King's Birthday in early June and in the days leading up to Anzac Day toward the end of April. This is likely a result of fishers travelling from neighbouring areas.

Retrieving a good estimate of total fishing effort is challenging when the fishery is spread over a wide area and fisher estimates of time spent in the water are important for estimating catch rates. The 2021–22 survey collected a sub-sample of actual time fishers spent in the water observed by an interviewer paired with the fisher estimated time when interviewed. This showed no significant bias in fisher estimated time in water and no adjustment to landed catch per hour was required in the previous survey (Holdsworth 2022). It is time consuming to collect these data and it was assumed that, on average, fisher estimated time in the water was unbiased. There were fewer hand gatherers/waders in the 2023 autumn survey than in the summer 2021–22 survey. Most pāua fishers in 2023 had mask, snorkel, and wetsuit. They spent longer in the water and generally targeted other species in addition to pāua. Days and areas with reasonable underwater visibility attracted increased fishing effort, and some of these were weekdays.

This was the first marine recreational survey in New Zealand to provide in-season running totals for harvest estimates. Weekly reports were provided to Fisheries New Zealand, who distributed them to some stakeholders, from 5 May 2023. The R code (R Core Team 2022) was written to duplicate the analysis and results from the 2021–22 survey and adapted to provide automated results and key graphical outputs. Some data formatting issues were encountered and initial CVs were high, in part because of the high variance in week day effort and catch.

The code used the length-weight relationship from Pāua Industry Council data when estimating the running totals. At the completion of the 2023 survey, all length and weight data collected were used to generate a new regression for use in the final harvest estimate. These weights at length were applied to the 2021–22 survey data which updated the harvest estimate from 42 t (CV 17.5) to 40 t.

The survey collected information on where the group of fishers interviewed normally reside. Christchurch and the Kaikōura region were where the largest proportion of people lived (Table A2). Far fewer groups had come from the North Island compared with the summer open season in 2021–22.

The addition of Oaro to the on-site survey interviews provided limited information for the fishery. The survey did not include a high tide stratum, but local conditions and local knowledge suggest there was little fishing effort at mid and high tide at these locations during the 2023 open season.

This was the first year where fishers had the option to report their catch on the Mainland Catch app. Information from interviewers suggests that there is a lack of knowledge of reporting capabilities and there was large uncertainty around whether fishers were reporting their catch with many returning for a second trip having limited recall of the app. A number of fishers also confused the Mainland Catch app with the NZ Fishing Rules app. There is support in the community for voluntary reporting of pāua catch but it will take time and much wider promotion to increase uptake before reporting rates can be evaluated.

The data and experience generated from the two recreational harvest surveys will assist managers evaluate the available 'levers' they have to provide the balance in sustainable utilisation and a fair allowance for amateur fishers in the Kaikōura Marine Area.

5. ACKNOWLEDGEMENTS

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7. APPENDIX

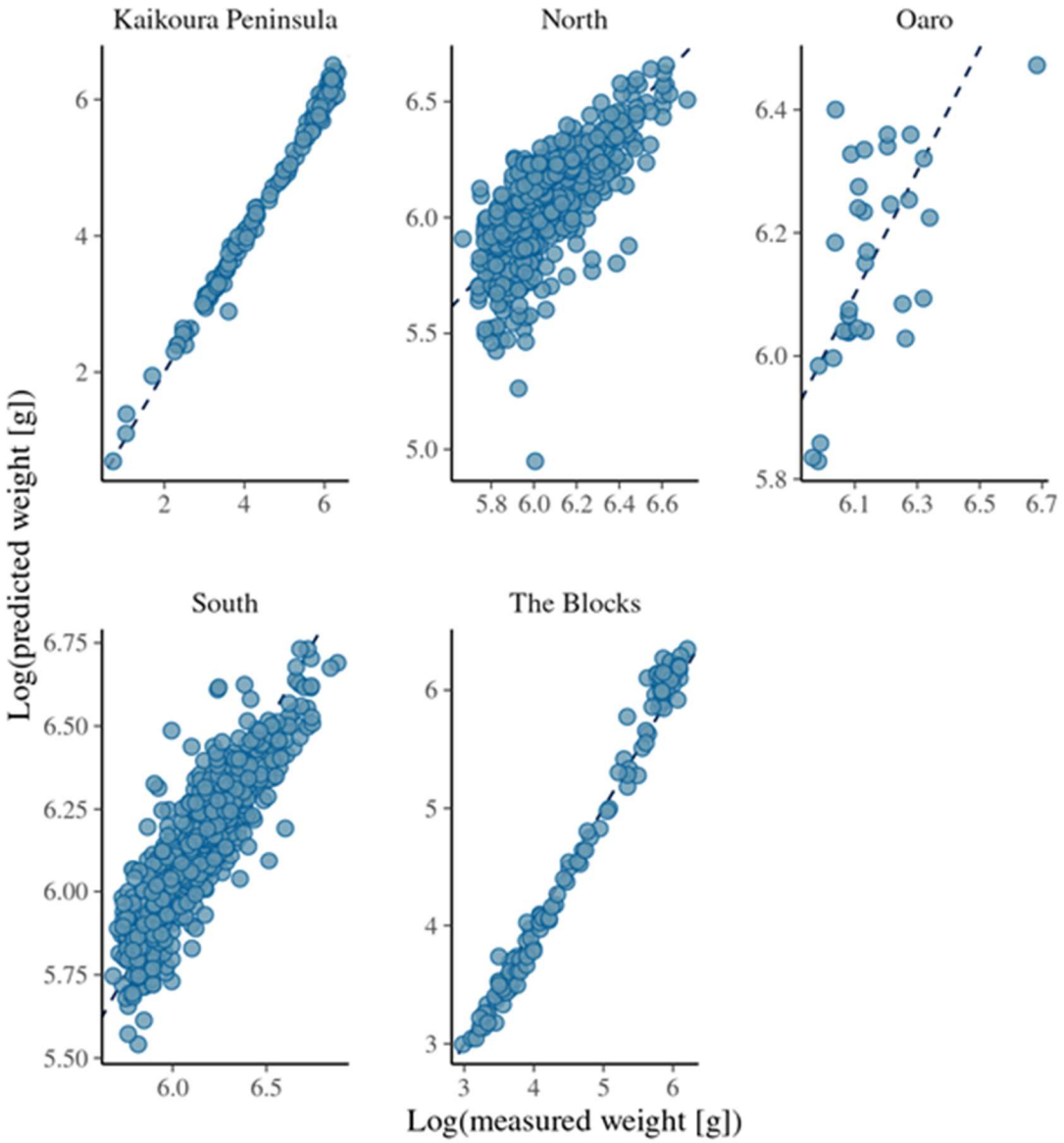

Figure A1: Predicted against measured weight from the length-weight regression model for different areas in the model.

Table A1: Pāua shell length frequency by spatial strata.

Length (mm)	North route	South route	Oaro
122	1		
123		1	
124		2	
125	8	8	
126	11	15	
127	10	16	
128	26	22	
129	20	25	
130	19	11	
131	19	42	
132	30	13	
133	27	24	
134	28	19	
135	22	23	1
136	21	17	3
137	23	11	
138	26	18	3
139	21	21	1
140	24	21	5
141	22	18	3
142	33	32	5
143	16	14	
144	16	29	
145	16	26	3
146	15	13	
147	13	22	2
148	14	17	2
149	6	7	
150	7	22	2
151	13	17	1
152	6	12	
153	7	6	
154	5	9	
155	6	5	
156	2	3	
157	2	6	
158	3	6	
159		5	
160		3	
161	5	4	
162	3	4	
163		2	
164		3	
165		4	
166	1	1	
167		3	1
168		5	
169			
170			
171			
172			
173		1	
174			
175		1	
Total	547	609	32

Table A2: Number of groups interviewed in the KMA by where they had travelled from by day type.

Origin	Weekend/Hol	Weekday	Total
Christchurch	179	55	234
Kaikōura	74	65	139
Blenheim	34	5	39
Nelson	22	13	35
Oaro	16	3	19
Rangiora	10	2	12
Picton	6		6
Westcoast	3	3	6
Queenstown	4	1	5
Cheviot	5		5
Auckland	3		3
Waikato	3		3
Ashburton	2		2
Methven	2		2
Motueka	2		2
Amberley	1		1
Masterton		1	1
Unknown	1		1
Total	367	148	515