Fisheries New Zealand

Tini a Tangaroa

Estimates of pāua harvest by land-based amateur fishers—Kaikōura Marine Area in 2024

Te Kāwanatanga o Aotearoa

New Zealand Government

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PLAIN LANGUAGE SUMMARY

This report outlines the findings of the 2024 onsite survey estimating the amateur harvest of pāua in the Kaikōura Marine Area, New Zealand. The fishery was closed after the 2016 Kaikōura earthquakes due to significant habitat damage and pāua mortality. Following public consultation and engagement with tangata whenua, the fishery reopened for a three-month open season in summer 2021–22. An onsite survey was designed and implemented to estimate recreational harvest from land-based access points.

This report describes the method and results for the third survey of amateur pāua harvest in the Kaikōura Marine Area, covering a 61 day open season from 1 April to 31 June 2024. A roving survey that counted the number of fishers in the water was used to estimate hourly fishing effort. Separate onsite interviews recorded catch per fisher when they had finished fishing. Oaro, south of the main survey area was included for a second year. Interviewers collected individual pāua weight and length from all surveyed catch.

Across the 27 survey days, clerks interviewed a total of 353 individual fishers and counted 1074 fishers in the water. The total recreational harvest for all daylight hours and days in the Kaikōura Marine Area was estimated to be 15.83 tonnes (CV 0.18), which is higher than the 2023 harvest estimate.

EXECUTIVE SUMMARY

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 harvesting to allow for protection of the remaining pāua populations and associated habitats. The fishery reopened for the first time in December 2021 for a three-month open season and has since been reopened year round for commercial fishers plus there have been two open seasons over autumn in 2023 and 2024 for recreational fishers.

The amateur pāua harvest survey was initiated to monitor catch and how the pāua stock responded to fishing pressure following the earthquakes. This report documents the third survey conducted to estimate the amateur harvest of pāua in the Kaikōura Marine Area, and the second survey to provide in-season weekly updates of harvest estimates during an open season in autumn. The surveyed 2024 open season lasted from 22 April to 21 June. The primary sampling unit in this survey was a random selection of days stratified by holiday/weekend days and weekdays. The opening week was split into two separate temporal strata to account for the first two opening days and a public holiday weekend. A single access point survey in Oaro was also included in the on-site interviews. Data for harvest estimates for rock lobster (*Jasus edwardsii*), yellowfoot pāua (*Haliotis australis*) and kina (*Evechinus chloroticus*) were also collected and analysed.

Wading and hand gathering or free diving with mask and snorkel were harvest methods used by pāua gatherers across high and low tide. 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 35 260 pāua were kept. Based on length and weight data collected, the amateur harvest estimate of pāua at Oaro for the survey period was 59.2 kg (CV 0.42) and the combined survey area was 15.83 tonnes (CV 0.18).

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

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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 pāua gatherers 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, resulting in a coastal uplift of up to 6 metres along 110 kilometres of coastline. This uplift led to extensive habitat modification and significant impacts on biodiversity in the area. 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 21% 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. Dive 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, 2018, 2021). Following public consultation (Fisheries New Zealand 2021) and input from tangata whenua, the Minister for Oceans and Fisheries agreed to subdivide the Canterbury/ Kaikōura PAU 3 quota management area into PAU 3A (Kaikōura) and PAU 3B (Canterbury) to allow better management of the recovering pāua stock. The recreational fishery reopened for a three-month open season over summer 2021–22.

To support a sustainable reopening of the fishery, the first survey of amateur pāua harvest was commissioned for the duration of the 2021–22 open 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" (Oceans and Fisheries Minister David Parker, 5 October 2021). The 2020–21 survey estimated a total amateur pāua harvest of 42 t (CV 17.5%), which was higher than the 2011–12 National Panel Survey estimate (Holdsworth, 2022).

Following feedback from tangata whenua, the Kaikōura Marine Guardians and the public, the pāua fishery was reopened during a quieter time of year in 2023, for a two-month season, and the daily bag limit for blackfoot pāua was reduced from five to three per person. The Oaro-Haumuri Taiāpure reopened for the duration of the 2023 and 2024 seasons, with a daily bag limit of 2 pāua per person and minimum legal size of 135 mm. A time series of dive surveys estimated that abundance in the Kaikōura Marine Area steadily increased from 2018–19 to 2021–22 and the level of abundance was sustained through to the 2022–23 fishing year and declined slightly in 2023–24 (McCowan & Neubauer, 2024).

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 by chance it did not recruit any panellists resident in the Kaikōura region. This survey estimated that over 90% of the recreational pāua harvest in the Kaikōura area prior to the earthquake was taken by shore-based pāua gatherers. The pāua fishery on the Kaikōura coast was closed during the 2017–18

National Panel Survey. The 2022–23 National Panel Survey estimated the recreational harvest to be 0.91 tonnes (CV 0.68) (Heinemann & Gray 2024), while the 2023 onsite survey using the methods described below estimated the harvest to be 11.66 tonnes (CV 0.25) (Holdsworth et al. 2023).

The 2023 survey of amateur pāua harvest estimate reported rolling weekly estimates to a reference group of stakeholders including Fisheries New Zealand representatives, Te Rūnanga o Kaikōura and Kaikōura Marine Guardians.

The fishery reopened to amateur harvest for the 2024 season on 22 April and finished on 21 June. This report documents the third survey to estimate the amateur harvest of pāua in the Kaikōura Marine Area and the second survey to provide weekly updates of harvest estimates.

The overall objective of Fisheries New Zealand research project MAF2023-05 was to undertake a survey to estimate the pāua recreational harvest in the Kaikōura region.
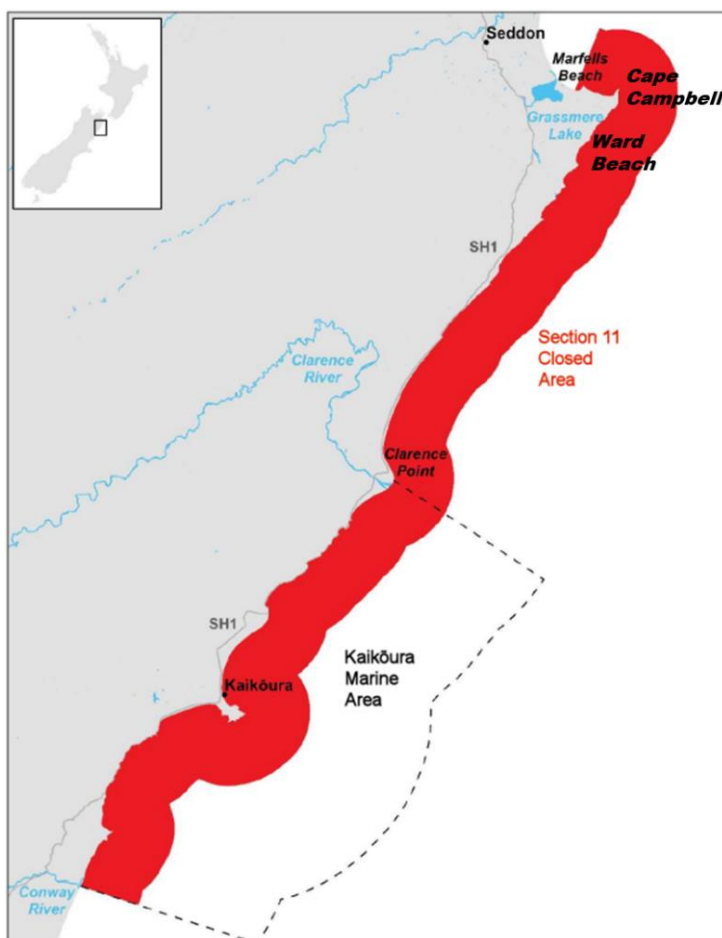

Figure 1: **The location of the Kaikōura Marine Area within the area closed to shellfish and seaweed harvest following the November 2016 earthquakes (red).**

2. METHODS

2.1 Kaikōura Marine Area survey

The Kaikōura Marine Area (KMA) extends from Clarence Point, south to Conway River (Figure 1). Much of this coastline consists of rocky shores and shallow reefs, which is ideal pāua habitat. Within this region, the Hikurangi Marine Reserve spans 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 was open for the duration of the 2024 season.

The 2024 survey followed the 2023 survey design, which was a refinement of the method developed by Blue Water Marine Research for the first amateur harvest survey in 2021–22 (Holdsworth 2021, Holdsworth 2022). The survey used a roving-access survey approach with an instantaneous count of fishers to estimate fishing effort, a count of parked vehicles, 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. Interviewers measured and weighed pāua and measured and sexed rock lobster (Holdsworth et al. 2023). A survey design for PAU 3, including a survey approach for the Kaikōura area, was initially proposed in 2016 by NIWA, but not implemented (Hartill 2023).

An interviewer was also stationed at the main access point at Oaro for 4-hour survey sessions during low tide, on the same stratified random set of days as the Kaikōura roving survey. Total harvest for this location was calculated following the direct expansion method, as described for the stationary interview sites in the 2021–22 and 2023 surveys (Holdsworth 2022, Holdsworth et al. 2023).

Access point surveys provide a number of advantages over off-site surveys, including the ability to directly observe and measure retained catches and interview fishers 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 amateur fisher pāua harvest which took place from 22 April to 21 June 2024. The primary sampling units are the survey days. The first two days of the open season were sampled to enable supervised project initiation and training and to capture any initial surge in fishing effort. Within each temporal strata, survey days were chosen at random with equal probability without replacement. No more than two consecutive survey days could be selected. A higher intensity of sampling effort was allocated to days when higher levels of fishing effort were expected, to ensure that more precise estimates of catch and effort were obtained, when survey day harvests were 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 acknowledged 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). The first week of the open season was a school holiday and Anzac Day fell in the middle of the week, 25 April 2024. The opening week was therefore split into two strata. Monday 22 April to Wednesday 24 April were allocated to a stratum to account for the initial weekdays of the season and Thursday 25 April to Sunday 28 April were allocated to a second stratum, to include Anzac Day, and the weekend acknowledging the likelihood that there would be an influx of fishers visiting for a long weekend. The remaining days occurring during the 2024 open season were allocated to either weekend/public holiday or weekday strata, with the former including King's Birthday on 5 June 2024. The survey design took account of the requirement to provide in-season updates of pāua harvest. The sampling intensity in the 2024 survey was higher than in both previous surveys of amateur pāua harvest, to help ensure reasonable precision in the weekly running total harvest estimates. There were 27 survey days consisting of the

first two opening days, two over the opening week public holiday weekend, 9 days across the remaining weekends and public holidays, and 14 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 length of each survey day, which were all less than 12 hours during the 2024 autumn open season. Within each tidal strata there was a randomised start time and location for the roving count of people in the water. The coverage of early morning and evening hours in tidal strata varied depending on the timing of the low tide on each survey day, to fit between sunrise and sunset.

Table 1: **Temporal sampling design for the recreational harvest survey starting on 22 April 2024.**

Day type	Days in stratum	Surveyed days	Sampling intensity
First week weekday	3	2	0.67
First week We/Hol	4	2	0.50
Weekend/holiday	15	9	0.60
Weekday	39	14	0.36
Total	61	27	0.44

2.3 Spatial stratification

The survey area covered 60 kilometres of coastline in the Kaikōura Marine Area, including sections not considered optimal pāua habitat. To ensure efficient completion of the roving fisher count, the survey area was divided into two spatial strata (Figure 2).
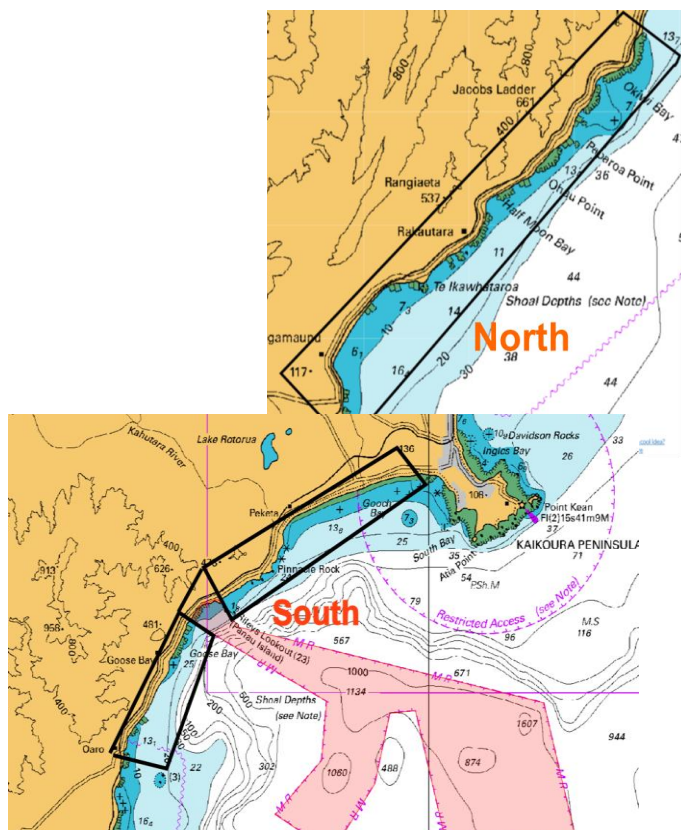

Figure 2: **The location of the spatial strata for the Kaikōura pāua roving survey in 2024. The Kaikōura Peninsula was not surveyed because pāua gathering was prohibited there.**

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 included the two-kilometre coastal boundary of the Hikurangi Marine Reserve. The primary survey area within the southern stratum extended approximately 15 km beside the road from Peketā to Oaro, much of which consists of gravel beaches unsuitable for pāua habitat (Figure 2). The Kaikōura Peninsula Taiāpure, closed this area to pāua fishing, and it was therefore excluded from the surveyed area. A third 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). Due to the lack of road access and appropriate vantage points, Oaro was not included in the main roving survey.

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 2024.

2.4   Survey approach

Each spatial stratum was divided into survey sections as defined in previous surveys. 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, Holdsworth et al. 2023). There were two 3-hour survey sessions per spatial stratum per survey day with a random start time preselected within the low and high tide strata.

The roving survey of fishing effort captured semi-instantaneous counts of pāua gatherers and people in the water. The roving counts required two survey clerks, one driving and the other spotting pāua gatherers in the water or parked vehicles. Survey clerks drove along the coastal highway, stopping at vantage points and popular pāua gathering sites. The start time, location, and travel direction of the roving survey were selected at random within each spatial and tidal stratum. This provided a point-in-time estimate of total effort for people potentially collecting pāua. For long weekends, a clockwise travel direction was adopted for the southern route to reduce the need to cross heavy traffic when pulling into carparks. Additionally, parked vehicles were counted at known pāua gathering locations. These counts may be used in future to support pāua fishing effort estimates. Data collected during the roving survey was recorded using the app 'Fastfield' on a tablet and were uploaded to the server at the close of each roving session.

For the fisher interviews in the north and south spatial strata, interviewers travelled 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 separate roving 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' lists pāua as a species that could be reported. Fishers were asked whether they would be recording todays catch on this app. The survey focus is amateur harvest, as 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 collected 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 each pāua fishing location provided a point-in-time estimate of fishing effort in each stratum and the separate interviews at the completion of each fishers trip was used to estimate a mean catch rate for each 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 I_{ij} is the randomly timed 'instantaneous' count of gatherers per hour made during the tidal stratum j on the survey day and T_j 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 using 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. Nested bootstrapping 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 2023).

2.7   Oaro survey

The Oaro survey area is located south of the main Kaikōura survey area and was also closed following the earthquakes. The beach has limited access through the village and across a railway line. Vehicle access has been blocked and most fishers access this area on foot or using four-wheel bikes. There are two customary management plans in place in Oaro; the Oaro-Haumuri Taiāpure which was open for the 2024 season, and the Oaro Mātaitai, which remained closed to all pāua harvesting (Figure 3). 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, as access was along the coast, where pāua on subtidal reefs were fished by divers rather than wading.

Survey clerks followed the same interview process as the main Kaikōura survey; but interviewers were not required to count the number of people in the water or parked vehicles.

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

3. RESULTS

All survey sessions on the 27 selected survey days were completed. Across the three spatial strata, 1073 people were observed in the water during the roving count sessions and there were 172 groups of fishers/gatherers with a total of 353 people in the roving interview sessions. The interviewers recorded 784 retained pāua, 93 yellowfoot pāua, 2 rock lobster, and 39 kina, with pāua harvest recorded on 23 survey days (Table 2).

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

Survey area	Counts of people in the water	Groups interviewed & fishing	Individual fishers interviewed	Landed pāua in interviews	Yellowfoot pāua in interviews	Rock lobster in interviews	Kina in interviews
North	489	67	140	344	27		
South	559	89	188	393	66	2	39
Oaro	25	16	25	47			
Total	1073	172	353	784	93	2	39

3.1 Length-weight relationship

The model fitted the length-weight data well, for individual areas and in aggregate, only the length-weight relationship at Kaikōura Peninsula appeared slightly different from the overall relationship found for the Kaikōura region (Figure 4). Compared to the 2023 length and weight data, pāua in 2024 were heavier for their length in all three spatial strata (Figure 5).

The model fitted the length-weight data for individual areas with the 2023 and 2024 survey data in aggregate (Figure 6). The estimated relationship is given by:

Weight = 2.7097e-05 x Length$^{3.3718}$

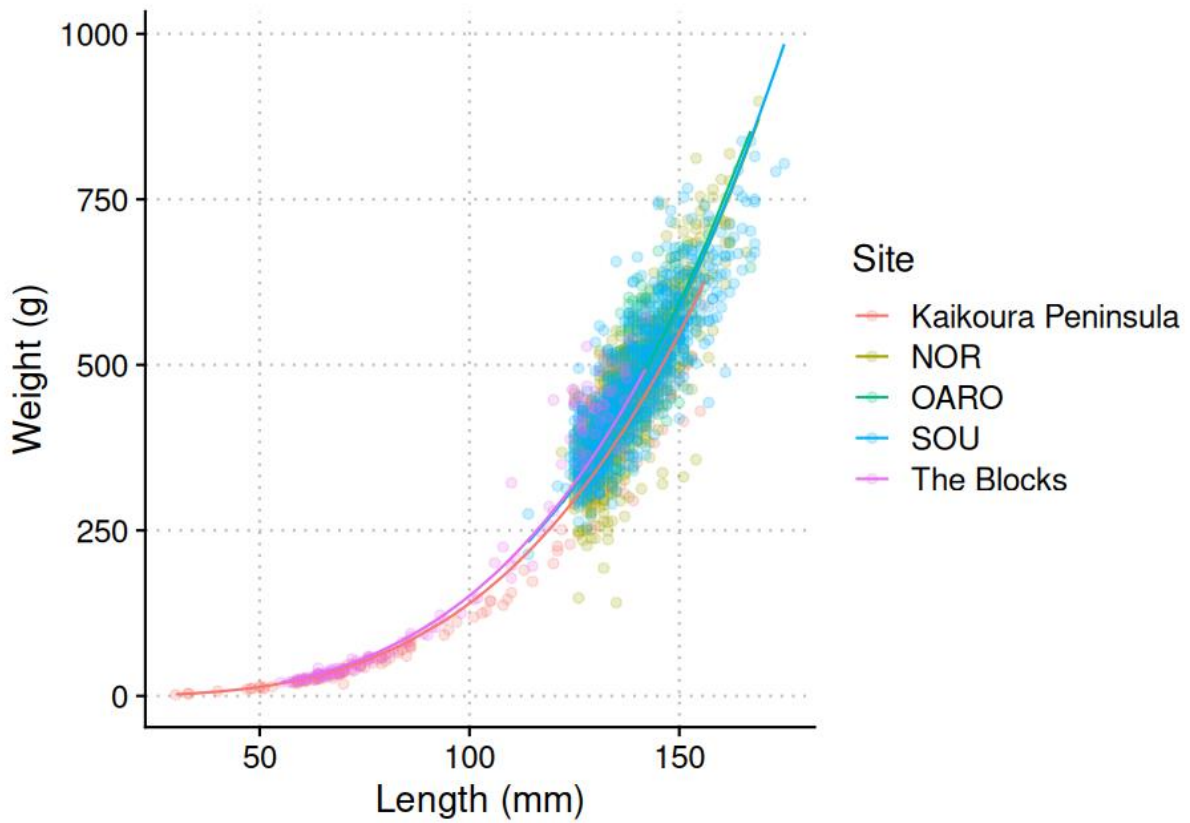where weight is in grams and length in millimetres.

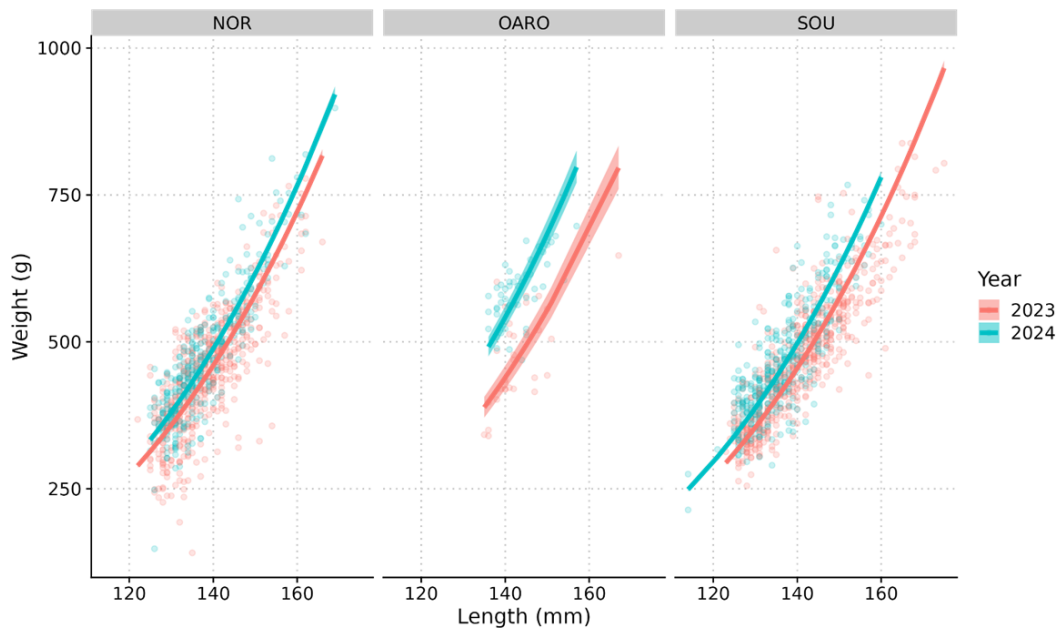**Figure 4: Pāua length and weight data by area and corresponding length-weight regression estimate.**

Figure 5: Pāua length and weight regressions for the 2023 and 2024 survey data by area.
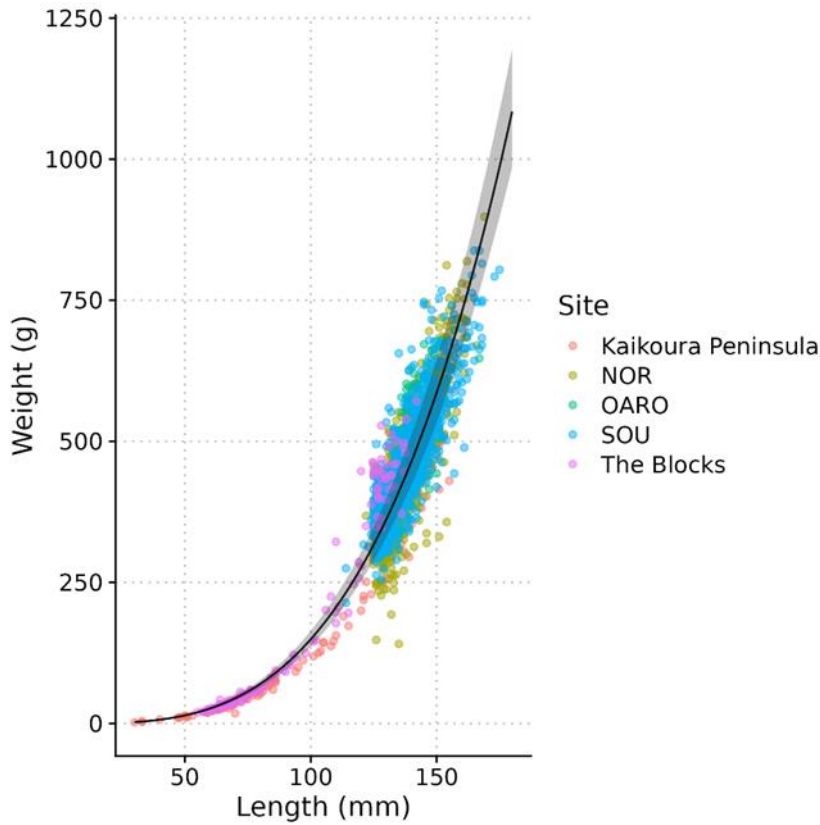
Figure 6: **Pāua length and weight data used to calculate harvest weights. The minimum legal size was 125 mm in the recreational fishery.**

3.2   Kaikōura Marine Area

Across the two roving survey strata in the Kaikōura Marine Area (KMA), the four survey days with no pāua catch intercepted were 22 May, 29 May, 13 June and 16 June 2024. Poor weather and sea conditions were more common in 2024 than in the previous surveys. The two days with the highest number of interviews were 25 April and 12 May (Figure 7). These were a public holiday and a weekend with favourable weather and swell conditions.
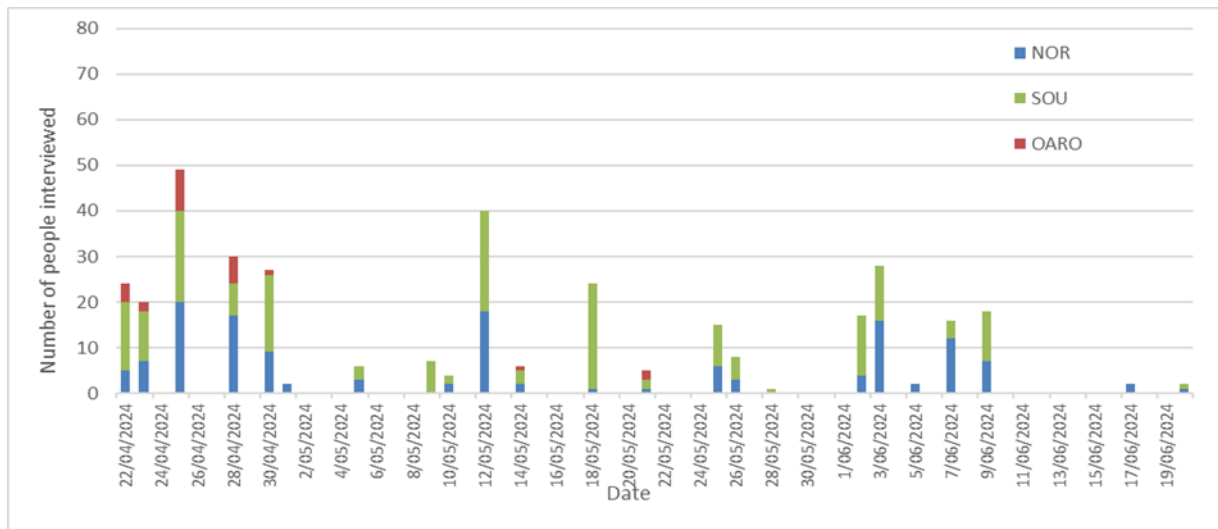

Figure 7: **The number of pāua gatherers interviewed by survey day and spatial stratum.**

Of the fishers interviewed who were targeting pāua, 66% caught and kept the daily bag limit of three pāua and a further 19% 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 remaining 15% of interviewed fishers recorded individual bags of one or two pāua (Figure 8).

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 9% of landed pāua weight. In the high tide stratum snorkelling was the only method used for 100% of time in the water.
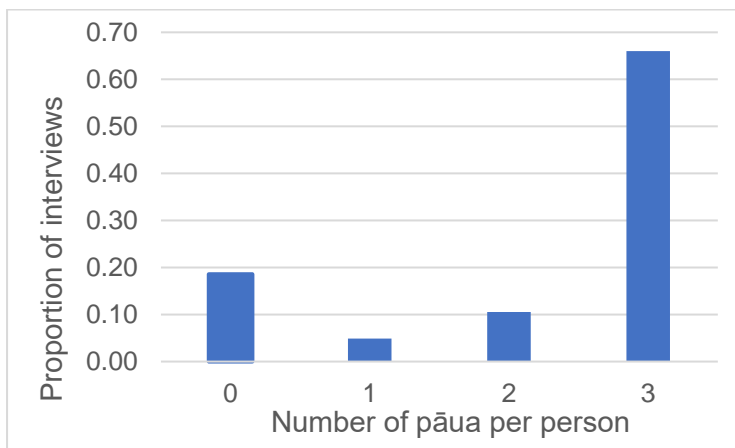

Figure 8: The number of pāua kept per person.

Pāua shell lengths were measured to the nearest millimetre rounded down and cooperation from fishers was generally very good, with 96% of observed pāua being measured. Less than 1% of the measured pāua were undersize, and most of these were returned to the sea. The pāua length distributions for the north route and south route were similar, with a spread of pāua lengths measured between 123 mm and 169 mm in the north and between 121 mm and 159 mm in the south (Figure 9, Table A1). When plotted as cumulative proportions, the lines diverge as there was a higher proportion of small pāua measured in the southern survey area, with the median at 135 mm (50% above and below) (Figure 10).
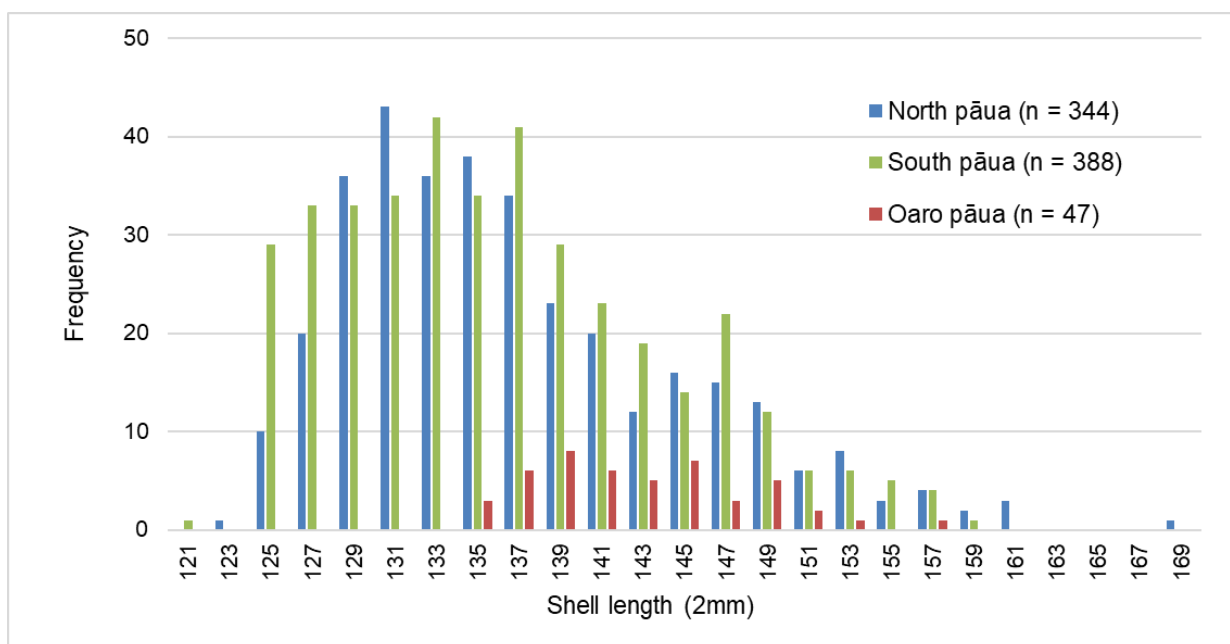
Figure 9:   Shell length frequency distribution of pāua by survey route in the Kaikōura Marine Area.
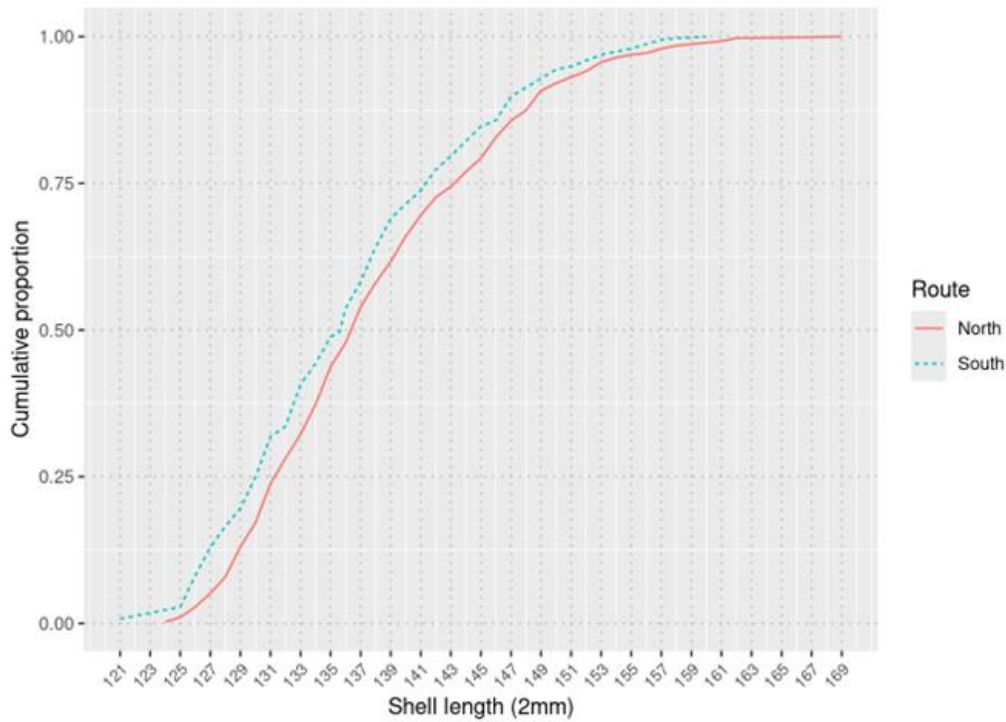
Figure 10: Cumulative proportion of pāua shell length by survey route in the Kaikōura Marine Area.

The estimated cumulative catch by week in the 2024 survey was higher than in 2023 in both the north and south routes. Weekly increases in the north were more consistent in 2024 than in the previous year, particularly after week five (Figure 11). Overall catch shows that most of the increase in 2024 comes from the first week (Figure 11) and the average catch for the remaining eight weeks is similar.

Figure 11: Cumulative estimated catch of pāua by survey route and week for the open seasons in 2023 and 2024.

Overall the survey estimated that 15.78 t (CV 0.18) of pāua were harvested recreationally from the north and south strata over the two-month period (Table 3). A high proportion of catch in 2024 was taken during the first week. The average harvest for the seven following full weeks was 1.21 t (week 9 was only 5 days long). Excluding the first week in 2023 the weekly average was 1.12 t. Fishing effort and pāua availability was higher in 2021–22 (Table 4).
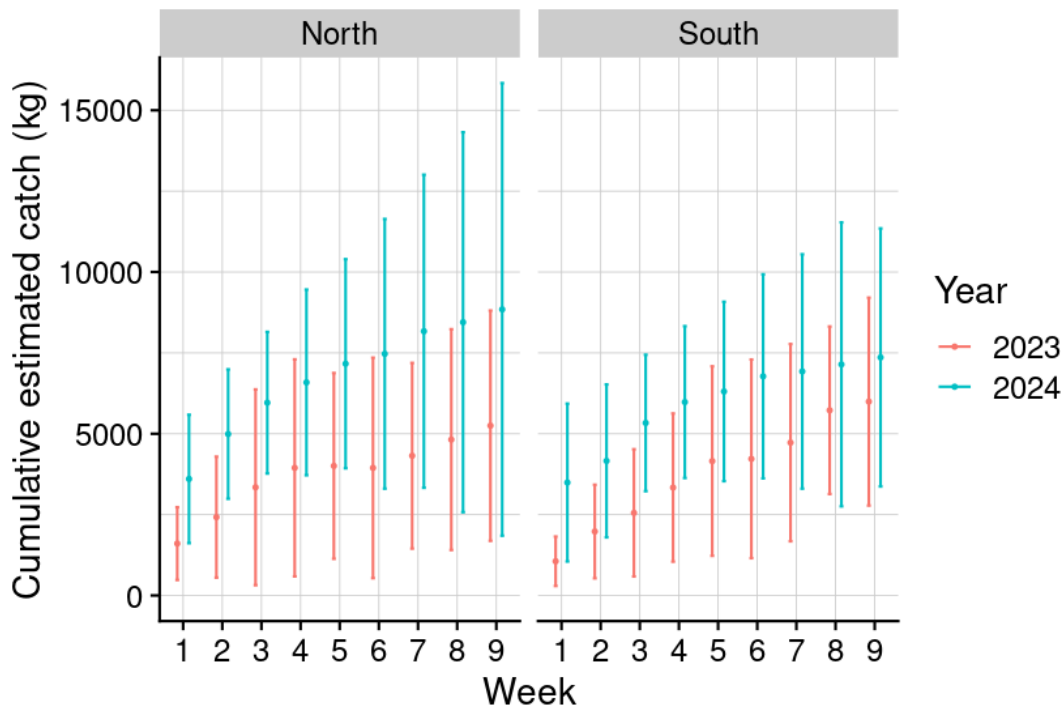
Table 3: **Cumulative pāua harvest weight, total number of pāua harvested and total hours of fishing effort estimated by week within the main survey strata in Kaikōura Marine Area in 2024.**

Week	Total pāua harvest (t)	CV	Number of pāua (1000s)	Effort hours (1000s)
1 Monday 22 April	7.09	0.19	15.03	4.47
2	9.15	0.17	19.81	5.79
3	11.29	0.15	24.84	7.45
4	12.57	0.15	27.80	8.33
5	13.47	0.16	29.90	8.86
6	14.25	0.13	31.71	9.45
7	15.09	0.15	33.66	9.99
8	15.59	0.18	34.83	10.32
9	15.78	0.18	35.26	10.38

Table 4: Estimated catch (tonnes) of pāua in the first week and the average catch for the remaining weeks by open season.

	Season		
	2021–22	2023	2024
First Week	6.84	2.74	7.09
Average for all other full weeks	2.83	1.12	1.05

The proportion of catch taken by wading and hand gathering has declined since 2021–22. Initially there were large pāua in shallow water and in that year sea conditions were favourable for this kind of fishing. Data collected in the 2021–22 survey found that 36% of catch by weight in the low tide stratum was taken by wading (Holdsworth 2022). In the autumn 2024 survey only 11% of pāua by number and 9% of pāua by weight was taken by wading, all from the low tide stratum. The average shell length of pāua taken by wading was 134.3 mm, which is smaller but not statistically different to those taken by snorkelling with an average of 137.4 mm (Figure 12).
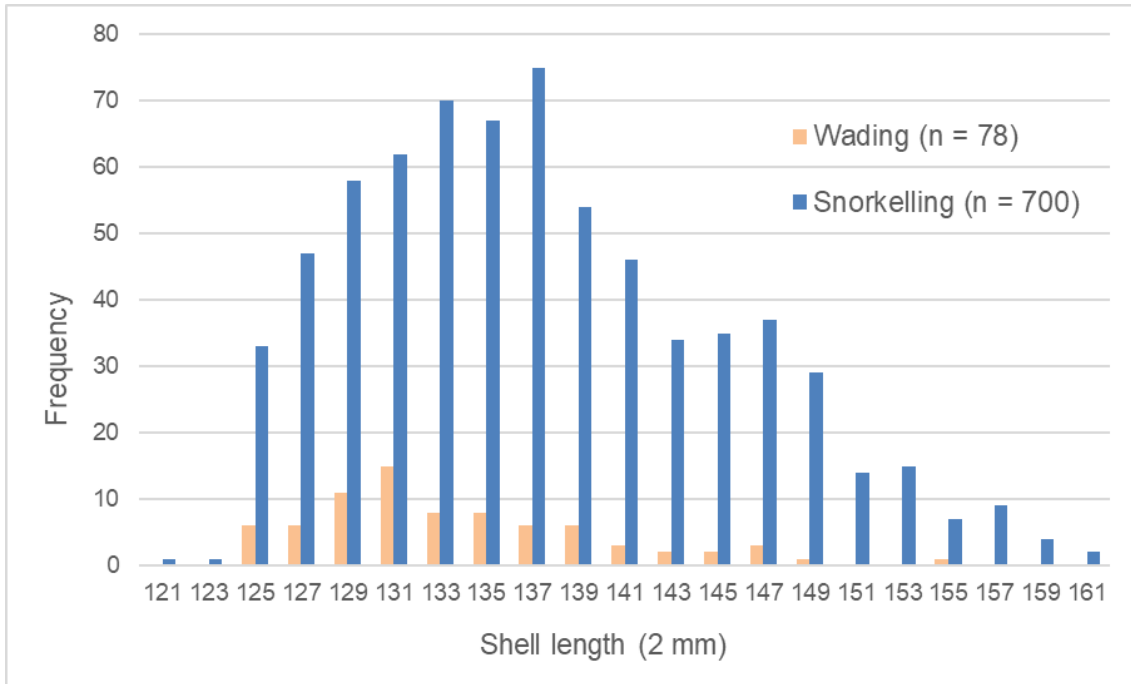
Figure 12: Shell length frequency distribution of pāua collected by fishing method.

3.3 Pāua caught and released

Fishers were asked how many pāua they removed from the rocks and released. Survey interviews reported 421 pāua released in the Kaikōura Marine Area. The total estimate scaled to all fishers for all days in the open season was 19 490 (CV 0.21) pāua released. This is 36% of the catch by number, not weight, because most pāua released would have been undersized or just over the legal size. Fifty-six percent of fishers said they did not remove any pāua from rocks that they did not keep; a summary of the numbers reported released per fisher is provided in Figure 13.
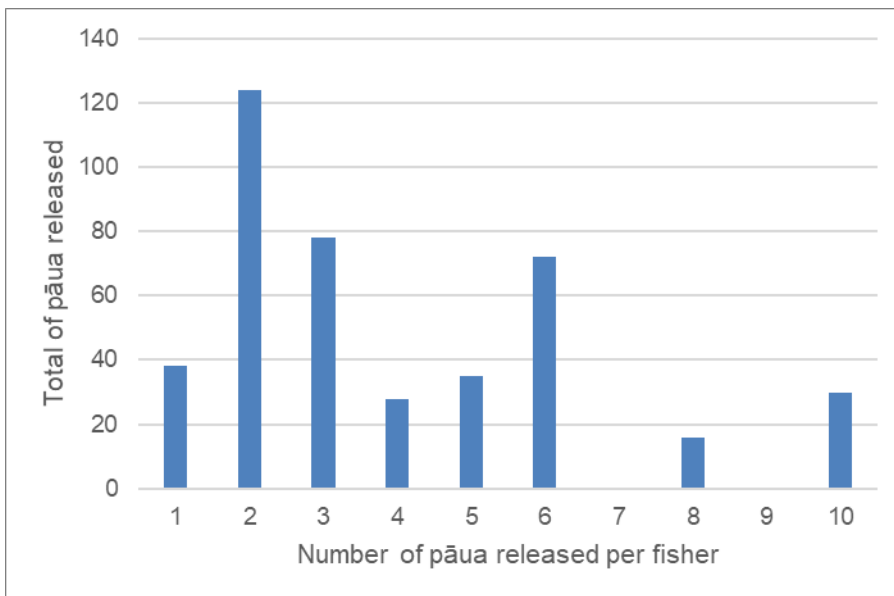
Figure 13: The number of pāua released per fisher from interviews in the Kaikōura Marine Area.

3.4   Spatial distribution of effort

The survey design divided the survey routes into 11 sections in the north and 10 in the south, to determine the spatial 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 so estimating harvest weights by section was not possible. Estimates of the number of people in the water over all 61 days show that effort was spread across the northern route, with seven sections between 150 and 330 fishers and two sections with about 650 fishers (Figure 14). In 2024 the southern route had effort concentrated (1350 fishers) in the section between the Hikurangi marine reserve and Goose Bay and to some extent around Boat Harbour (610 fishers).

Figure 14: Estimated number of people in the water totalled over all 61 survey days by survey section.

3.5   Oaro survey results
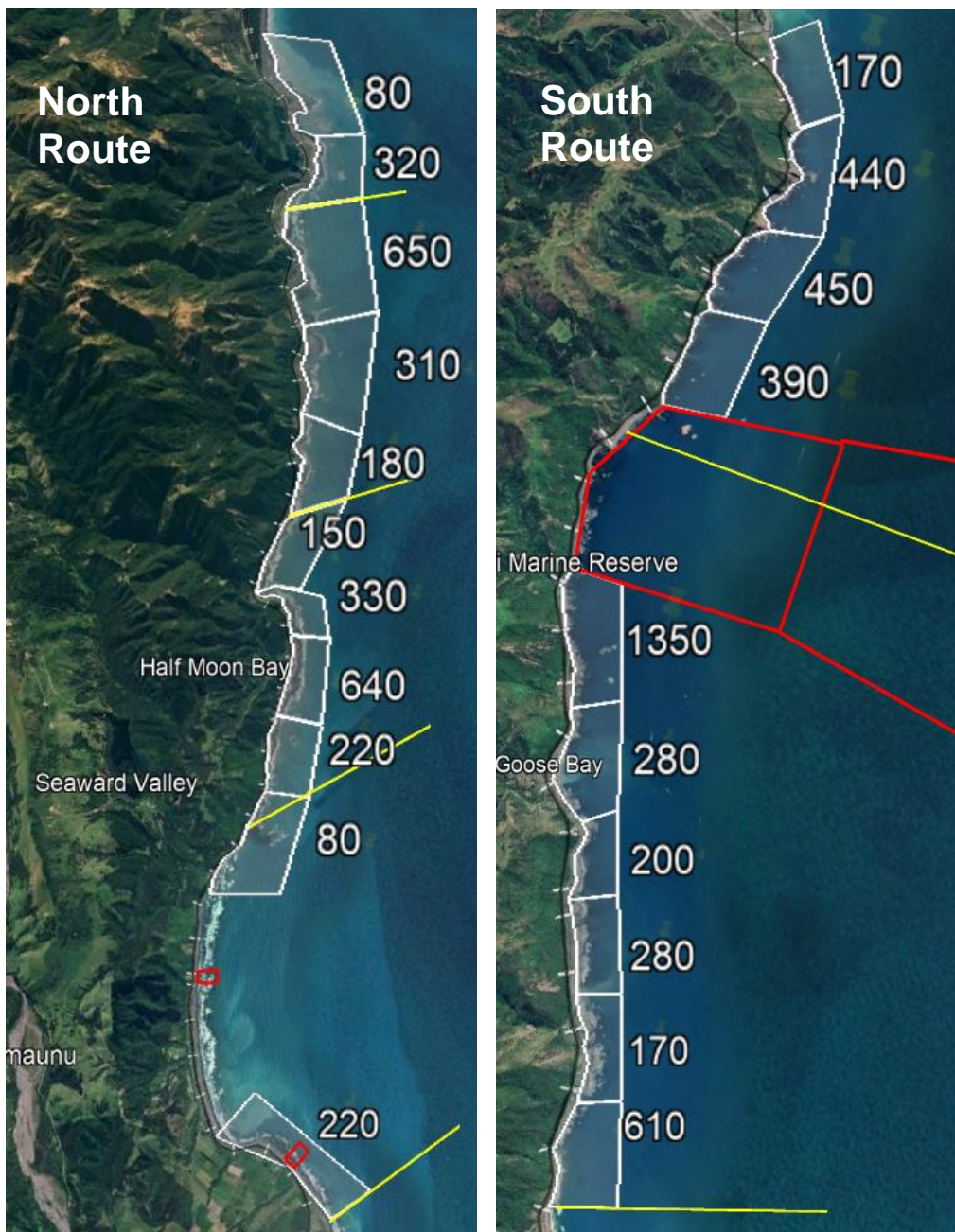
Oaro was not included in the 2021–22 survey due to restricted road access, but there was some concern that a large number of pāua were taken from that area that had not been accounted for. Four-wheel drive vehicles and motorbikes were used to travel along the shore to areas with shallow reefs.

Prior to the 2023 survey, 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 this rail crossing had a lower daily bag limit of two per person and a minimum legal size (MLS) of 135 mm, which is a larger MLS than for 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. The interviewer was able to note the level of effort on non-survey days. There was very little. From 108 survey hours there were 25 fishers interviewed, mostly locals, and 47 pāua recorded. Scaled up to all survey days the harvest estimate for south of Oaro was 59.2 kg (CV 0.42).

3.6   Harvest estimates for other species

There were two 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. Both rock lobsters were recorded from interviews in the southern stratum. The total estimate of rock lobster harvest in this survey was 120 (CV 1.11) for the combined Kaikōura survey area (Table 5).

Table 5: 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
Total	120	1.11	2 120	0.83	4 220	0.38

There were 93 yellowfoot pāua kept by hand gatherers and fishers snorkelling and recorded during interviews in the main survey area. All kina harvested was recorded in the southern survey area. No size or weight data were collected. The expanded harvest numbers for kina and yellowfoot pāua are provided in Table 5.

3.7 Mainland Catch app reporting

In 2023, Fish Mainland (with support from the Ministry for Primary Industries through the Sustainable Food and Fibres Fund) developed an app for recreational fishers to record their catch for a range of popular species in the South Island. There has been an opportunity to gauge participation rates of fishers during the 2023 and 2024 onsite pāua harvest surveys. Pāua was added to the Mainland Catch app shortly after the opening of the 2023 pāua harvest season and people were generally not aware that it was available. In 2023, the survey interviewers told fishers about this app and asked whether each fisher was going to report their catch on the app. In 2024, the survey question about whether a fisher was going to use the app to record their catch that day was asked before explaining what the app was and where to get it, and their response was recorded. Of the fishers that had pāua catch and who responded to this question, 3 fishers (1.32%) said they were aware of the app and intended to use it to record that day's catch.

4.   DISCUSSION

The pāua fishery is of high value to all fishing sectors and Kaikōura is a highly accessible, iconic region for amateur fishers. The instantaneous pāua gatherer counts provided by the roving-access survey provided an estimate of fishing effort and separate on-site interviews of fishers were used 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.

Following the 2016 earthquakes, significant highway reconstruction was needed along parts of the north and south routes. This has prevented access to the shore in areas that were once popular pāua gathering sites. In addition, ongoing temporary road construction has prevented pāua harvesting along sections of the coastline, resulting in increased pāua gathering in more sheltered, accessible locations.

This was the third broad scale survey in Kaikōura, with 27 (44%) of the 61 available days being surveyed. The high sampling rate assisted with producing weekly running totals of harvest and helped to get a representative sample of days across the temporal strata. All allocated days were successfully surveyed, but fishing effort was highly variable due to changeable autumn weather conditions with no catch reported on four surveyed days. Fishing effort peaked on and around public holidays and weekends with ideal harvest conditions, including Anzac Day during the first survey week and on King's Birthday in early June. This is likely to be attributable to fishers travelling from neighbouring areas.

Obtaining 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 direct observations for a sub-sample of fishers of the actual time that they spent in the water that could be compared with the fisher estimated time when interviewed. This comparison indicated no significant bias in fisher estimated time in water and no adjustment to landed catch per hour was required (Holdsworth, 2022). It is time consuming to collect this data and for the 2024 survey it was assumed that, on average, fisher estimated time in the water was unbiased. There were fewer hand gatherers/waders in the 2024 autumn survey than in the previous two years. Most pāua fishers in 2024 used masks, snorkels, and wetsuits. They spent longer in the water and spent time targeting other species in addition to pāua. Days and areas with reasonable underwater visibility attracted increased fishing effort, and some of these were weekdays.

For the second consecutive year, this survey provided in season running totals for harvest estimates, and this is the only recreational survey in New Zealand that has provided such regular update estimates. Weekly reports were provided to Fisheries New Zealand, who distributed them to relevant stakeholders. R code (R Core Team, 2022) was written to duplicate the analysis and results from the 2021–22 survey, which was further 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 survey collected information on where fishers interviewed normally reside. The majority of fishers came from , Kaikōura or Oaro (26%) or Christchurch (49%) (Table A2). Far fewer fishers had travelled from the North Island compared to the open season in summer 2021–22 and autumn 2023. A decline in fishers travelling from further distances may be attributable to timing of the shorter open season, fewer days with ideal harvest conditions over this time of year and the lower bag limit of three pāua per person per day.

The addition of Oaro into 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 2024 open season, with a 26.6 kg increase in catch from the 2023 estimate (32.6 kg) (Holdsworth et al. 2023).

The 2022–23 National Panel Survey PAU 3A harvest estimate of 0.91 t (CV.68) is implausibly low and is significantly lower than what had been estimated in the 2023 onsite survey (11.66 t) (Holdsworth et al. 2023). Nationwide offsite surveys of specialist fisheries with relatively few active fishers can be inaccurate and imprecise due to low sample sizes. While the regional telephone surveys in the 1990s have largely been dismissed they do contain information on harvest and harvest rates. These surveys underestimated the proportion of the population that fished but tended to recruit more avid fishers. There were biases both ways which cannot be quantified. The 1991–92 regional survey of recreational fishers estimated the PAU 3 harvest to be 122 000 pāua (CV 0.30) and 35 t to 60 t which seems plausible for the fishery open year round with a bag limit of 10 per person in the Canterbury and Kaikōura regions at the time. The onsite survey method used by this, and the previous two onsite surveys, are likely to be far more accurate and reliable amateur harvest estimates for these limited open seasons.

This was the second year when 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 New Zealand Fishing Rules app. There is some 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 for pāua can be evaluated.

5.   USE OF SURVEY INFORMATION

The PAU 3A Total Allowable Catch (TAC) was reviewed prior to the October 2024–25 fishing year. The Total Allowable Commercial Catch (TACC) was increased to 46 t, the recreational allowance was increased to 18 t, and the Māori customary allowance remained at 7 t. In addition, the Minister decided to increase the recreational minimum legal size to 130 mm shell length. Potentially, these changes could allow for a longer open season for recreational fishers if it occurred at a similar time of year. The average catch from the 2023 and 2024 two-month seasons is around 14 t, with a high proportion of fishing effort and catch coming from holiday periods with reasonable weather. The increased size limit may result in the continued decline in the catch taken by wading, but an increase in average weight of pāua harvested by fishers with snorkelling gear if the availability of large pāua remains high. The 2024 survey had a higher proportion of catch removed then released than in the previous surveys. The proportion of catch released will probably increase as fishers adjust to the new size limit.

The data and experience generated from the three recreational harvest surveys across multiple seasons will assist managers to evaluate the available 'levers' available to provide the balance in sustainable utilisation and the allowance for amateur fishers in the Kaikōura Marine Area in future.

6.   FULFILMENT OF BROADER OUTCOMES

As required under Government Procurement rules[3], Fisheries New Zealand considered broader outcomes (secondary benefits such as environmental, social, economic or cultural benefits) that would be generated by this project. The following broader outcomes were delivered:

This project helped employ people in rural New Zealand and the Kaikōura region. These surveys assisted fisheries managers to have confidence in the harvest controls used and open the recreational fishery which is an important resource for the local community and brings visitors into the region. Survey interviewers were able to help by answering questions from the public on fishing rules, appropriate harvesting tools, and compliance with the regulations was high.

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[3] https://www.procurement.govt.nz/procurement/principles-charter-and-rules/government-procurement-rules/planning-your-procurement/broader-outcomes/

Sydney Curtis was responsible for interviewer training and communications in 2024. She conducted the wrap up survey at the completion of field work and assisted with the Marine Amateur Fisheries Working Group presentation and report writing. Sydney is Ngāti Hine and has been connecting with her whakapapa through lessons with her kaumātua and kuia, in addition to taking Te Reo courses at the local Unitec. Sydney was also a Māori STEM ambassador at AUT for prospective Māori students moving into an environmental and marine science career.

7. ACKNOWLEDGEMENTS

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9. APPENDIX

Table A1: Pāua shell length frequency in 2024 by spatial strata.

Length (mm)	North route	South route	Oaro
121		1	
122			
123			
124	1		
125	3	8	
126	7	21	
127	9	19	
128	11	14	
129	20	12	
130	16	21	
131	26	27	
132	17	7	
133	16	28	
134	20	14	
135	25	18	
136	13	16	3
137	24	18	
138	10	23	6
139	10	19	4
140	13	10	4
141	9	9	5
142	11	14	1
143	4	9	3
144	8	10	2
145	4	10	5
146	12	4	2
147	9	16	2
148	6	6	1
149	11	6	2
150	2	6	3
151	3	2	1
152	3	4	1
153	6	4	
154	2	2	1
155	2	2	
156	1	3	
157	2	3	1
158	2	1	
159			
160	2	1	
161	1		
162	2		
163			
164			
165			
166			
167			
168			
169	1		
Total	344	388	47

Table A2: Number of fishers interviewed in the Kaikōura Marine Area by where they had travelled from by day type.

Origin	Weekend/Holiday	Weekday	Total
Christchurch	117	50	167
Kaikōura	34	40	74
Nelson	29	1	30
Blenheim	20	2	22
Oaro	7	7	14
Canterbury	7	5	12
North Canterbury	4	7	11
Auckland	2	1	3
North Island	3		3
Wellington	2		2
Total	225	113	338