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Tini a Tangaroa

Pāua amateur harvest survey design for the Kaikōura Marine Area

New Zealand Fisheries Assessment Report 2021/63

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The commercial and recreational fisheries for pāua (*Haliotis iris*) have been closed since November 2016 from Marfell's Beach to the Conway River. The region experienced a series of significant earthquakes that caused large coastal uplift of up to 6 metres, which caused extensive habitat modification and mortality of a wide range of species in the intertidal and subtidal zones. Pāua were particularly affected with very high mortality at all life stages and loss of a significant number of critical habitats.

A marine recovery package was put in place that included a long-term monitoring programme to quantify the recovery from the earthquake and inform future marine management decisions. Survey data suggest that juvenile and adult pāua abundance has rebuilt to the point where sustainable harvesting can occur. The Kaikōura Marine Guardians recommend a cautious approach to reopening the pāua fishery in Te Whata Kai o Rakihouia i Te Tai o Marokura - Kaikōura Marine Area. Fisheries New Zealand has run a consultation process and the Minister has decided on an initial reopening period from 1 December 2021 for a three or four month period.

The Kaikōura Marine Area has previously supported a productive and popular recreational fishery for pāua with many access points from State Highway 1, which runs along the coast for about 60 km. This report documents a proposed design for an on-site survey to estimate the amateur harvest of pāua in the area. It builds on design work that was undertaken by NIWA in 2016 which was not implemented due to the closure of the fishery.

A roving-access survey method is proposed with two components: an instantaneous count of potential pāua gatherers in the water during a transit of the coast, to provide a point-in-time estimate of total effort in each spatial and temporal stratum, and a separate concurrent on-site access survey to conduct interviews of fishers at the completion of trips as they return to their vehicles to estimate catch per unit effort.

The proposed sampling frame will be all the days in the open season stratified by holiday/weekend days and weekdays. The primary sampling unit will be a random selection of days within each day type stratum, apart from the first four fishable days after opening that will all be surveyed to capture the anticipated surge in fishing effort and to refine survey implementation. In addition, secondary sampling units will be two tidal strata, a four hour low tide stratum and an eight hour mid/high tide stratum. It is proposed to define the length of the fishing day as the time between sunrise and sunset at Kaikōura.

Three spatial survey strata are proposed to ensure that the instantaneous count of fishers can be achieved in a relatively short time within each stratum. The start time, start location, and direction of travel will be selected at random within each spatial and tidal stratum. The survey will require five people per survey day, two people for the roving component and an on-site interviewer in each spatial stratum.

A method for calculating harvest estimates using the roving-access design is described; this uses the product of an estimate of the total effort occurring within a spatio-temporal stratum and an associated mean catch rate.

[1] Blue Water Marine Research, 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 mortality of a wide range of species in the intertidal and subtidal zones. Pāua were particularly affected with very high mortality at all life stages and loss of a significant number of critical habitats. The amount of the pāua fishery area lost to the uplift has been estimated to be 20% of previously fished areas.

To protect the surviving pāua populations and associated habitats, as well as other shellfish and seaweed resources, a fishery closure was introduced between Cape Campbell/Marfell's Beach and the Conway River (Figure A1). The fishery would remain closed until the Minister considers ongoing monitoring of the area suggests juvenile and adult pāua abundance has rebuilt to the point where sustainable harvesting can occur. The closure under section 11 of the Fisheries Act 1996 does not apply to rock lobster, scampi, and octopus fishing, or to customary fishing.

A marine recovery package was put in place to assess the ecological impact of the earthquake and to inform future marine management options to optimise recovery of biota and habitats in the region. As part of this package, two research projects have been conducted that are relevant to pāua:

- *Rocky reef impact quantification and monitoring for the Kaikōura earthquake*. The objective of this project was to quantify the impact of the Kaikōura earthquake on rocky reef intertidal and subtidal fauna and either quantify or establish long-term monitoring sites to quantify the recovery from the earthquake to inform future marine management decisions. This provides quantification of the number of pāua juveniles at selected locations in the lower intertidal.

- *Pāua stock monitoring survey for the Kaikōura region*. The objective of this project was to estimate and monitor the abundance of adult pāua populations to inform management decisions at the scale of the Kaikōura fisheries closure.

The Kaikōura Marine Guardians recommend the reopening of the Te Whata Kai o Rakihouia i Te Tai o Marokura - Kaikōura Marine Area to pāua fishing from 1 December 2021. This area extends between the Clarence River in the north and the Conway River in the south (Figure A1). There is significant local interest in the opening of this fishery and, with high numbers of large pāua in easily accessible (shallow) areas, there is potential for a very active recreational fishery.

Fisheries New Zealand consulted on changes to the pāua recreational daily bag limit, minimum legal size (MLS), and length of the open season (Fisheries New Zealand 2021). The Kaikōura Marine Guardians recommended an amateur daily bag limit of 3 per person, a vehicle limit of four daily bag limits or one pāua per person, whichever is greatest, an MLS of 130 mm, and a three month pāua season from 1 December 2021 to 28 February 2022.

On 5 October 2021, the Oceans and Fisheries Minister David Parker announced, "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,"

Changes to the Amateur Fishing Regulations take time to introduce. For this open season the previous recreational bag limit of five pāua per person per day, an accumulation limit of 10 pāua per person for a multi-day trip, and the minimum legal size of 125 mm will remain. Appropriate monitoring of the amateur harvest of pāua in the area will form an important component of stock assessments, and any future fisheries management decisions in the region.

In 2016 a survey was designed by NIWA to estimate annual recreational harvest of pāua across the whole of the PAU 3 recreational fishery, which includes Kaikōura (Hartill 2016). This design was accepted by the Marine Amateur Fisheries Working Group, but not implemented because of the earthquakes and fishery closure that followed. A stratified random selection of days would be surveyed using a semi-instantaneous count of pāua gatherers in the water made during a single transit along the Kaikōura Coastal Highway and Kaikōura Peninsula to provide a point-in-time estimate of total effort within each spatiotemporal and tidal stratum. A random start time, location, and direction of travel would be preselected and all people below the water's edge would be considered to be gathering (unless this was obviously not the case). A roving creel survey of pāua gatherers would provide the number of pāua harvested and time in the water per person to calculate the mean catch rate per stratum. Pāua length measurements would be collected to provide weight estimates from a length-weight regression.

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 did not recruit any panellist resident in Kaikōura (by random chance). The overall NPS estimate for PAU 3 was 17 t from 35 panellists with 80% taken using shore-based methods. The proportion of shore-based harvest in the Kaikōura area was over 90% prior to the earthquake, in part because fishing parties cannot take pāua when they have scuba gear on board their boat (Hartill 2016). The pāua fishery on the Kaikōura coast was closed during the 2017–18 NPS survey.

A project to monitor recreational catch rates and harvest size distribution for blue cod (*Parapercis colias*), sea perch (*Helicolenus percoides*), and rock lobster (*Jasus edwardsii*) in the North Canterbury–Kaikōura area by surveying boat ramps at Motunau and Kaikōura was undertaken in 2012–13 (Kendrick & Hanley 2021). This was a year round on-site bus route survey of the main launch sites in those areas and line fishing was the most common method used. In the Kaikōura area, 1931 fisher interviews on private vessels were completed and pāua was the fourth most common catch by number with 221 caught and 98% retained. The other main species recorded were sea perch (5518 caught with 58% retained), rock lobster (5015 caught with 50% retained), and blue cod (1551 caught with 50% retained) (Kendrick & Hanley 2021). NIWA are conducting a repeat bus route survey of boat ramps from Motunau to Kaikōura for the 2021–22 fishing year under Fisheries New Zealand project MAF2020-05.

There are no previous surveys of shore-based pāua amateur harvest in New Zealand. There have been regular amateur harvest surveys for Roe's abalone (*Haliotis roei*), a unique shore-based fishery in the Perth region of Australia. The ease of access and high density of this highly prized species on the doorstep of a major Australian metropolitan city makes it susceptible to overfishing and has resulted in this fishery being one of the most restricted recreational fisheries in the world. In the early 1980s amateur harvest was restricted to a two month open season. The season length has been progressively shortened since then and since 2010 the season has been open for 1 hour per day on 5 days during November and December. In 2018–19, over 16 000 abalone recreational licences were issued for this fishery (Lachlan Strain, DPIRD, pers. comm.). Each open day observers at twenty shoreline vantage points overlooking high use areas count fishers in the water every 10 minutes, and aerial video is used to count fishers in low use areas, to estimate total fishing effort per hour. On-site interviews collect information on the time spent in the water and number of abalone kept, to estimate catch per fisher hour. The harvest estimate is the product of total effort and the catch rate (Hancock & Caputi 2006).

In Tasmania, off-site phone-diary surveys of abalone and rock lobster recreational fishers have been undertaken from November to April every second year using a random sample from their species-specific recreational fishing licence-holder data bases. In 2020–21 there were 407 respondents, with 344 abalone licence holders completing the survey (71% effective response rate). They provided

detailed catch and effort information for each fishing trip undertaken which was scaled up to represent the activity of all 11 700 abalone licence-holders (Lyle et al. 2021).

The overall objective of this research project (SEA2021-01) is to design a survey to estimate the pāua recreational harvest in the Kaikōura region.

2. METHODS

Large sections of State Highway 1 run along the coast of the Kaikōura Marine Area (KMA). About half of the 60 km road passes rocky shores and shallow reef where pāua are likely to be found. The Hikurangi Marine Reserve includes a two kilometre coastal boundary at Raramai and there are five customary management areas which currently don't have specific harvest rules for pāua. Most of the information about the area fished and the changes since the earthquakes has come from people familiar with the area. Google Earth images and Google Maps street view have been useful although they are few years old. It would have been preferable to see the current condition of foreshore access and vantage points in person but there has not been time for this. Several on-site survey methods have been considered that take account of the dispersed nature of the fishery from carparks and roadside verges along the coast.

The draft New Zealand Fishery Assessment Report produced by Bruce Hartill (NIWA), for a survey design for all of PAU 3, included a survey approach for the Kaikōura area (Hartill 2016). The survey design for 2021–22 survey will have to take account of a much higher level of fishing effort over a shorter period than in 2016–17 when the fishery was open year round.

Survey approaches using a roving survey with a random stratified temporal design are the methods of choice when on-site fisher data are needed and fishing access is diffuse or inaccessible to stationary clerks (Pollock et al. 1994). Fisher effort is typically measured in fisher hours and harvest rate, or catch per unit effort, and is usually a measure of all fish kept per fisher hour. Some catch may be released with some associated but unobserved fishing mortality which may be estimated separately.

The roving-roving survey method used for land-based fisheries overseas generally has an instantaneous or progressive count of fishers to estimate effort and on-site interviews of fishers while they are still fishing to estimate the catch rate per hour. However, short trip times and restrictive bag limits will bias harvest estimates from incomplete trips (Pollock et al. 1997).

The roving-access survey method uses an instantaneous or progressive count of fishers to estimate effort, and separate interviews of fishers at the completion of trips ensures that fishers are intercepted with the same probability regardless of the length of their fishing trip. The appropriate catch rate estimator for this method is the ratio of means estimator (i.e., mean catch divided by mean effort) for each stratum (McCormick et al. 2012).

The aerial-access method has been used to estimate amateur harvest of finfish from boat-based fisheries in New Zealand (Hartill et al. 2011, Hartill et al. 2019). The method is conceptually identical to the roving-access design but has different practical implications. Aerial surveys can cover large areas relatively quickly to get an instantaneous count of fishing effort but observing all people in the water is harder than counting boats. Plane or helicopter trips are expensive, and they may not be able to fly due to poor visibility during inclement weather, although fishing may still occur. Flying conditions for fixed wing aircraft can also be difficult on fine days due to severe turbulence caused by strong offshore winds (Hartill 2016).

People gathering pāua will be concentrated in a relatively narrow strip of coastline and in future the use of drones programmed to fly a predetermined flight path, altitude, and speed could be considered. The instantaneous counts of pāua fishers could be made by reviewing the video record instead of counts made from a moving car or from vantage points at car parks.

Some of the specific considerations for designing the Kaikōura pāua harvest survey are:

- About 60 km of coastline is accessible from the coastal highway in the survey area.
- There have not been previous on-site surveys, so information on the nature and extent of amateur harvest of pāua is primarily anecdotal.
- This is an exposed coast facing southeast that is subject to storms and occasionally large swells on fine days.
- Ease of access to pāua will be affected by the state of the tide, although the tidal range at Kaikōura is not large, 1.1 m to 1.9 m (Land Information New Zealand)
- There are a number of carparks and campgrounds that extend 100s of metres along the coast that cannot be treated as a single access point.
- NIWA will be surveying boat-based marine amateur fishers over the 2021–22 fishing year to monitor harvest rates of key species in North Canterbury–Kaikōura (Fisheries New Zealand project MAF2020-05).
- Survey requirements need to be discussed with fisheries management and science staff at Fisheries New Zealand and Fisheries Officers.
- Producing harvest estimates by the sub-area used in the PAU 3 stock assessment may be required.
- The survey design will include an overall consideration of the survey objectives, logistics, cost, and respondent burden.

3. PROPOSED SURVEY DESIGN

Access point surveys have a number of advantages over off-site surveys. They involve direct observation by survey clerks of retained catch and interviews to collect information on fishing effort and methods are conducted immediately after fishing has occurred, minimising recall bias (Connelly & Brown 2011, Pollock et al. 1994). Accurate biological information may be collected on the length or weight of individual fish/shellfish, species identification is more certain, and, for rock lobster, the sex can be determined. Access point surveys are more efficient if survey clerks are stationed at choke points such as boat ramps. The Kaikōura pāua fishery is dispersed across a defined area and a roving component of the survey will be required. The spatio-temporal sampling frame consists of all times available for fishing (days or part days) during the survey period and the physical locations of the fishery (sections of the coast).

3.1 Temporal stratification

It is not necessary or affordable to sample all the days during the survey period. Survey days are the primary sampling units and are chosen at random with equal probability from all the days available without replacement. Where fishing effort varies considerably, stratification of sampling effort is used. Typically, there are seasonal strata (summer, winter) and day type strata (weekend/public holiday, weekday). More frequent sampling when fishing effort is higher will result 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 are likely to provide easier access and attract the higher fishing effort.

The proposed temporal sampling frame for the Kaikōura pāua survey is based on a single high use season starting from 1 December with two day type strata (weekend/public holiday and weekday) and two tidal strata (low tide and mid to high tide). There is an extended holiday period around Christmas and New Year. In 2021–22, all days between 25 December to 9 January should be included in the weekend/public holiday stratum. Two tidal strata per survey day are proposed. A low tide stratum of four hours, two hours each side of the predicted low tide for Kaikōura, and a mid/high tide stratum of eight hours to cover the full tidal cycle. It is important to have a clearly defined day length and the time of sunrise and sunset at Kaikōura is a practical baseline to use. The coverage of early morning

and evening hours in the survey will vary with the time of low tide on the randomly selected survey days because day length can be longer than the 12 hour tidal cycle over summer.

3.2 Spatial stratification

The Kaikōura pāua survey area covers about 60 km of coastline north and south of the Kaikōura Peninsula. Three spatial survey strata are proposed to ensure that the instantaneous count of fishers can be achieved in a relatively short time within each stratum. The proposed northern stratum from Waipapa Bay to the Hāpuku River is about 20 km by road beside rocky coast with many shallow reefs. The central stratum is the Kaikōura Peninsula with some road access but also will need the survey clerk to walk to vantage points above the cliffs to complete the roving count. The main pāua reefs are off the end of the peninsula. The proposed southern stratum starts at Kaikōura, but large gravel beaches do not have suitable pāua habitat. The main survey area is from Peketā to Oaro which is about 15 km by road. It includes Hikurangi Marine Reserve which has a 2 kilometre coastal boundary running south from Riley's lookout (Figure A2).

3.3 Survey approach

The proposed roving survey will make an instantaneous count of pāua gatherers (and people in the water with them) during a transit of the coast, to provide a point-in-time estimate of total effort for people that may claim a pāua catch. The start time, start location, and direction of travel will be selected at random within each spatial and tidal stratum. The roving survey will require two people in the car, one driving and the other counting pāua gatherers in the water. At larger carparks or areas that are not visible from the road the clerks will need to park to take an accurate count. It is proposed that these roving clerks cover both the north and south strata and it is expected to take 90 minutes to complete. The time to reach check points at selected locations will be standardised to ensure the time to complete each spatial stratum is similar for busy and quiet days. The central strata roving count will be made using a random start time, location, and direction by the on-site interviewer assigned to that area within each tidal stratum.

Each spatial stratum will be divided into sections that can be used for recording instantaneous counts of pāua gatherers and to identify the start and stop locations for the on-site interviewers. Ten to 20 sections are proposed for the north and south strata and 6 to 8 sections for the central strata (Figure A3). Final definition of the size and location of sections should consider fitting to mahinga mātaitai and taiāpure boundaries and on-site evaluation of vantage points and visibility from the road will be required. Total fishing effort and harvest rates can be calculated by spatial stratum or subdivided to fit with the commercial fishing strata used in the stock assessment. Consideration will need to be given to how the roving survey data will fit into the *rec_data* database. Fields in the tables t_session, t_observer, and t_obs_count are appropriate, but some modification or new fields may be required.

The proposed on-site survey will have an interviewer for each spatial stratum to collect pāua harvest and fishing effort data. These clerks will also have to travel between access points using a pre-determined random start time, location, and direction in each tidal stratum that may be different to the roving survey. A three hour survey session is proposed using a similar approach to a bus route survey with fixed wait times at key locations that are roughly proportional to the expected level of fishing effort. The clerks would intercept groups at the end of their fishing trip as they return to the carpark and collect information on: the time of the interview; the number of people in the water (fishers and non- fishers); pāua retained catch per person; time in the water per person; pāua released per person; method used; shell length measurements; yellowfoot pāua (*Haliotis australis*); and place of residence. Interviews should also collect information on the number, sex, and size of rock lobster harvested. The survey focus is amateur harvest, customary harvest will be recorded separately.

Interviewers will ask to measure all pāua taken. Participation in the survey is voluntary and some fishers may refuse. It is recommended that interviewers have scales to weigh the combined total pāua

catch for groups that are in a hurry or less cooperative. This is only useful if time in the water information is also collected.

Catch and effort will be summed by day type, tidal strata, and spatial strata. The catch rate of pāua kept per hour fished will be calculated using the ratio of means estimator. It is important that good estimates of time spent in the water are recorded, particularly when catch rates are high and time spent fishing is short. It is recommended that when an on-site clerk arrives at a carpark with a good view of the water that they record the time that they observe the first group or person enter the water and the time that they leave the water. This group or person should then be interviewed when they return to the carpark and their own estimate of fishing time recorded. It is likely that when fishers estimate the time they spent in the water they will round it off to 5, 10, or 15 minutes for example. Having data on actual time and estimated time will help determine whether there is a significant bias in one direction.

If fishers are in the water spearfishing or targeting other species this should be recorded during the on-site interview. The roving survey counts all people in the water, regardless of their activity at the time, so total minutes in the water must be used when calculating the pāua catch rate. The same definition of gatherers and people in the water must be used for the roving survey and the on-site survey.

3.4 Calculating 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 pāua gathering 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 pāua catch rate for a given day type/tidal stratum kj is estimated 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 should be expressed in terms of both numbers of pāua taken and weight. Catch weights should be calculated from catch-at-length data by applying a length-weight relationship derived from pāua measured and weighed from the surveyed area. Concurrent data from pāua surveys or the commercial fishery may be the best source of length-weight data. Harvest is summed across strata and variance estimates will be calculated by a non-parametric bootstrapping of trips within bootstrap days then days within strata.

An adjustment could be made to the harvest rate if a significant bias is detected in fishers estimated time in the water. This could be presented as a sensitivity to the unadjusted harvest estimate.

Final harvest estimates should include recreational boat-based harvest from concurrent NIWA bus route survey and amateur fishing charter vessel reporting. Also, the s111 amateur catch reported by commercial fishers from the Kaikōura area should be included.

4. SURVEY COST ESTIMATES

Survey cost is a consideration for the survey design and was requested by Fisheries New Zealand. This will be the first on-site survey of amateur harvest of pāua in Kaikōura and New Zealand. There is an opportunity to collect baseline data to help with the design of future surveys and to compare with other off-site methods of recording amateur harvest of pāua in the Kaikōura area. However, the situation is not typical because the fishery has been closed for five years and a limited open season has been proposed. It is expected that fishing effort will be high as soon as the fishery opens and over the Christmas and peak summer holiday period, as well as prior to the season closing.

The proposed design has a relatively high proportion of survey days and an additional temporal stratum during the first week, to capture harvest data during the anticipated initial surge in fishing effort. The example below is based on this approach and other assumptions about the opening date and the length of the open season.

Assuming a three month open season starting on Wednesday 1 December 2021, there would be 37 days in the weekend/holiday temporal stratum and 53 days in the weekday stratum. It is proposed that the survey is run on the first four fishable days of the first week. If there is a storm and large swells this will be considered unfishable. The first four survey days will allow for additional on-site training, because there will be no pāua fishery to train interviewers on prior to opening day. A detailed review of practical aspects of undertaking the roving and access point surveys will be undertaken after this initial period.

A total of 27 survey days are proposed from the 90 days available, giving a sampling fraction of 30%. The weekend/holiday stratum would have a sampling fraction of 31% and the weekday stratum 25% (Table 1). The highest level of survey sampling is proposed for the first week, which will be treated as a separate temporal stratum.

Table 1: Proposed temporal sampling design for the Kaikōura pāua survey assuming a three month open season starting on 1 December 2021.

Season	Day type	Days in stratum	Surveyed days	Sampling intensity
	First week	7	4	0.57
Summer	Weekend/holiday	35	11	0.31
	Weekday	48	12	0.25
	Total	90	27	0.30

Survey cost estimate for a three month survey is based on 27 survey days with 29 hours of survey clerk time per day consisting of:

- The roving component requires 2 clerks for 2 tidal sessions 2 hours long, which includes 30 minutes travel time to and from the random start and finish location. 8 hours total.
- The on-site component requires 3 clerks for 2 tidal sessions 3.5 hours long, which includes 30 minutes travel time to and from the random start and finish location. 21 hours total.

An allowance for the tier one Inland Revenue mileage reimbursement rate of 79 cents per kilometre and a paid training session has been included. Using the proposed survey approach the cost estimate is $94,000 excluding GST.

5. DISCUSSION

Pāua are highly valued by all fishing sectors and Kaikōura has been a focal point for the amateur fishery in the past. There is likely to be considerable interest from locals and visitors in gathering pāua when sea conditions allow. An on-site survey method collects good information from direct observation by survey clerks of retained catch and fishing effort. Interviews are conducted immediately after fishing has occurred, so recall bias is minimised and accurate biological information on the length or weight of individual fish can be collected. It is important to structure the survey well to get a random stratified sample of days, tidal state, and location to provide an unbiased estimate of total fishing effort and catch rate. A relatively high proportion of available days are proposed to be surveyed because rough sea conditions may reduce fishing effort on a proportion of the randomly selected days and because this is the first survey of its kind in this fishery.

A critical component of this on-site survey is the estimate of average catch per unit effort. Individual fishing times may vary with swell size, water temperature, visibility, or removal of most accessible pāua. Short harvest times and full bag limits could produce very large harvest estimates when scaled up to all the hours in the fishing day. It would be helpful to include some information about the survey, and the questions that will be asked, in the publicity or educational material produced prior to the opening of the pāua fishery.

Existing amateur harvest estimates for pāua are based on off-site methods including Telephone Diary Surveys between 1991 and 2001, which had difficulty scaling diarist catch to the New Zealand population, and the two National Panel Surveys which had a population proportionate sample of about 7000 fishers from a random sample of statistical mesh blocks. Unfortunately, the 2011–12 NPS did not include a mesh block in the Kaikōura district, and all off-site surveys have problems with the precision of harvest estimates for specialist fisheries with limited data, such as pāua and rock lobster at the scale of quota management areas. The sample size of pāua fishers in smaller areas like the Kaikōura Marine Area are even more problematic.

A health and safety plan for the survey could cancel a survey day in storm conditions when the road conditions are bad and there is the risk of rock falls. Landslides could cause road closures or traffic delays. Given the response to the global pandemic in New Zealand there is a risk that Covid-19 restrictions will interrupt fishing and the survey during the open season. Protocols will need to be developed to survey the fishery under level 2 restrictions that require social distancing and may limit travel.

6. ACKNOWLEDGMENTS

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APPENDIX A – SURVEY LOCATION AND SPATIAL STRATA

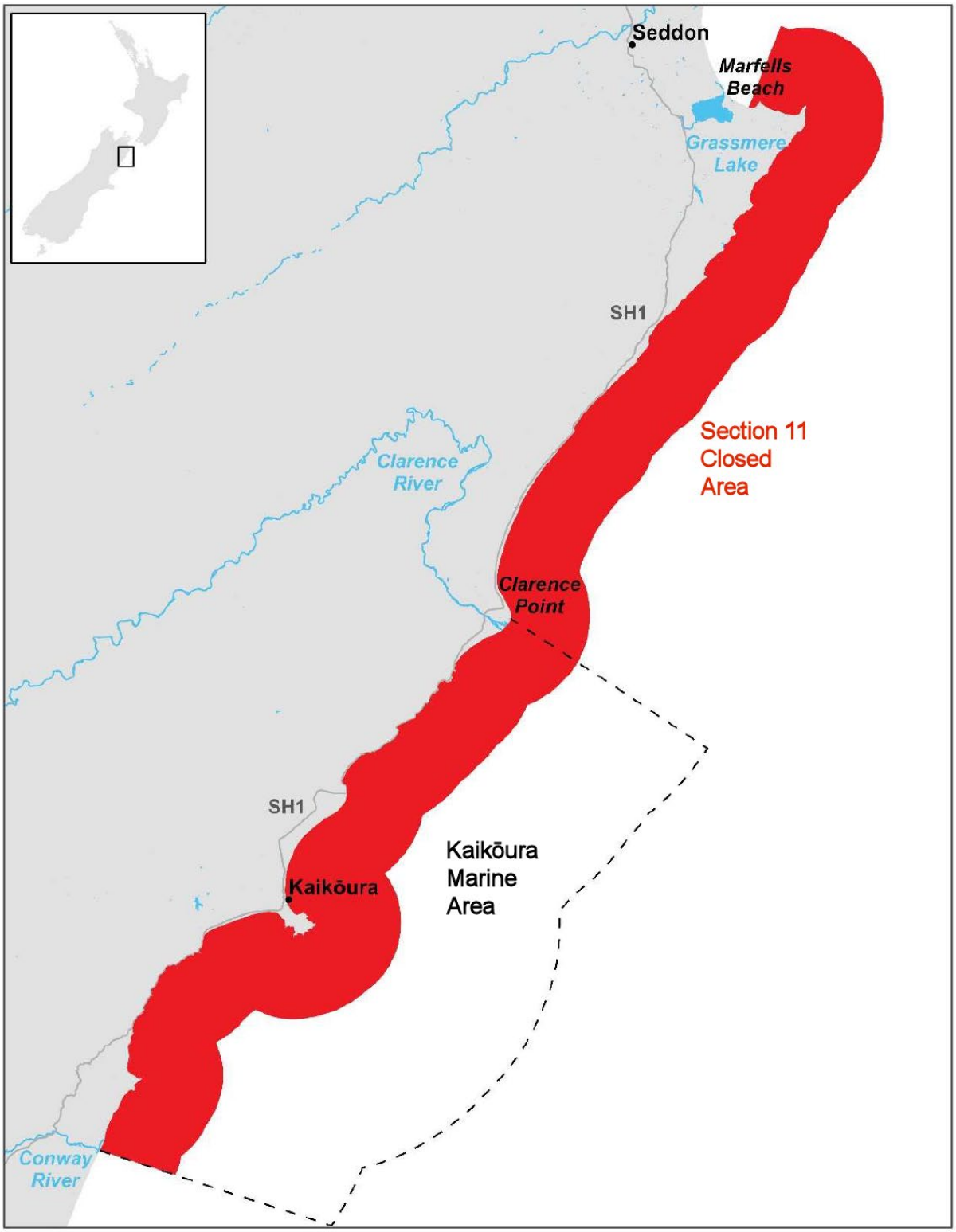
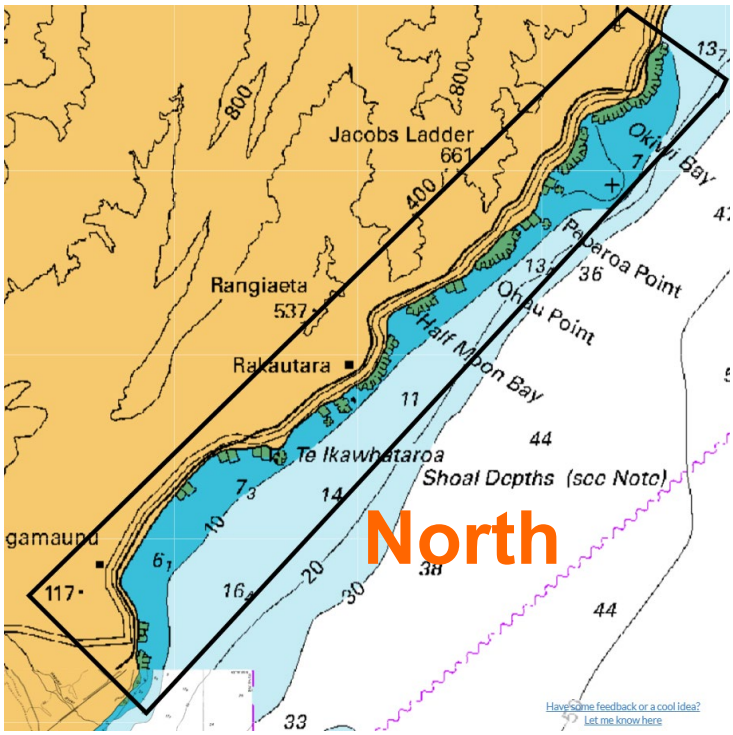


Figure A1: The location of the Kaikōura Marine Area and the area closed to shellfish and seaweed harvest since November 2016 (red).



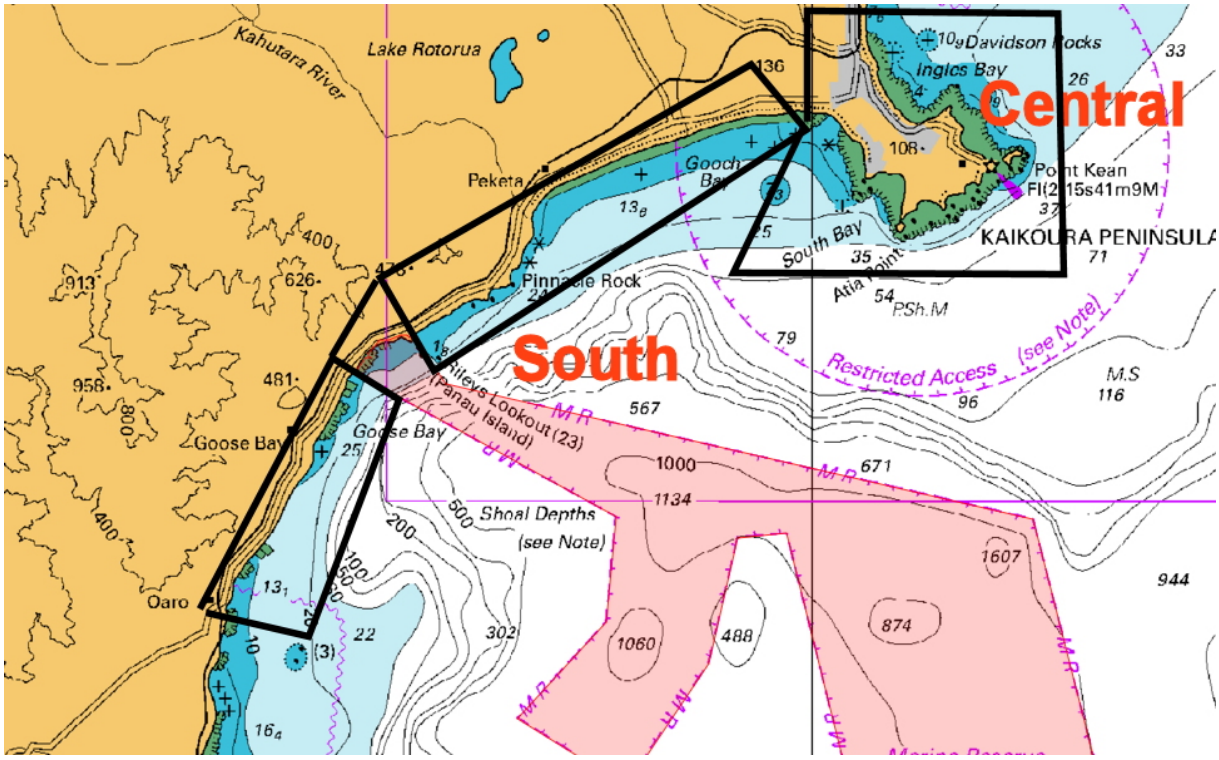


Figure A2: The location of the three proposed spatial strata for the Kaikōura pāua survey.

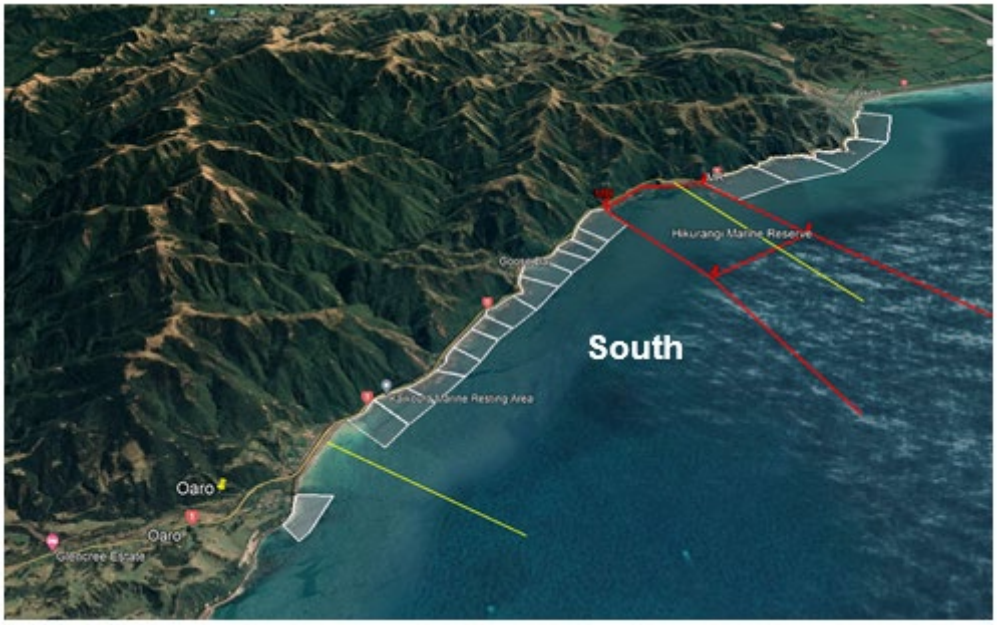


Figure A3: The proposed sections (white) used for recording fishing effort and catch rates within the three spatial strata and boundaries of pāua statistical areas (yellow).