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Who is catching what? A survey of recreational fishing effort and success on the East Otago Taiāpure

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About this report series

He Kohinga Tangahau is the research report series of *Te Tiaki Mahinga Kai*, a national coalition of tangata kaitiaki, researchers and managers dedicated to sustained enhancement of the cultural, economic, social and environmental well being of Māori and New Zealand as a whole through the application of *mātauranga* and science associated with mahinga kai to modern customary fisheries practices. See www.mahingakai.org.nz for a detailed description of the kaupapa. *He Kohinga Rangahau* means "the gathering together of research findings".

The report may be used and cited by anyone with due acknowledgement to *Te Rūnanga o Ngāi Tahu* who are directing and funding the overall project.

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Executive Summary

A survey within East Otago Taiāpure has been trialed to allow *kaitiaki* to measure (i) recreational and customary fishing activity, (ii) an index of fish stock levels, (iii) degree of compliance with recreational fisheries regulations, (iv) awareness and effectiveness of local regulations, and (v) a population profile (ethnicity, age, gender, residency and experience) of people fishing in the *taiāpure*.

The main measures being sought were:

- The type and number of shellfish and finfish species being harvested within the East Otago Taiāpure
- The type and number of shellfish and finfish being harvested beyond the *taiāpure* (by those launching from within the *taiāpure*)
- Catch per unit effort as an index of stock abundance
- The most recreationally targeted species within the *taiāpure*
- The proportion of fish kept versus released
- The level of catch regulation compliance for each targeted species
- The predominant types of fishing methods / gear used
- The attributes of recreational fishers (ethnicity, age, gender)
- The origin of recreational fishers and distance travelled to fishing site
- The effect of several environmental conditions (including swell, wind direction, wind speed, tide, water clarity, sea state and weather conditions) on recreational fishing activity

Awareness of the purposes and regulations of the taiāpure. Once repeated at 3-5 year intervals the surveys can access trends in stock levels and user profiles to guide the kaitiaki on sustainability and the need or otherwise to intervene with local regulations.

Intercept survey results suggest that the majority of recreational fishers fish within the *taiāpure* rather than venturing outside the *taiāpure*. The majority of those within the *taiāpure* targeted shellfish over finfish. Indeed shellfish gathers

comprised 64% of all survey respondents. Those venturing outside the *taiāpure* targeted only finfish. Cockles and *pāua* were the two most sought after shellfish comprising 43% and 27% of the total shellfish take respectively. Blue cod was the most targeted finfish, with 21% of fishers within the *taiāpure* and 80% of fishers outside the *taiāpure* recording blue cod catches. Increased fishing pressure just beyond the *taiāpure* and reach of bylaw restrictions may affect finfish metapopulations, the roaming ranges of which may expand within and well beyond the *taiāpure*.

The relationship between kept and released catch was species specific. A high percentage of most shellfish species were kept, with the exception of *pāua* where up to a third of caught individuals re-released. As *pāua* are particularly sensitive to damage, we suggest that discarded *pāua* ripped from rocks may be irreparably damaged and may increase the recreational 'take' of *pāua* by up to a third. In contrast, a higher proportion of some finfish species were discarded than kept. The relatively high release rate of blue cod, wrasse and parrot fish was attributed primarily to undersized catch.

The level of compliance with recreational fishing regulations was generally satisfactory among all main targeted species at the time of surveying, with the potential exceptions of blue cod and cockles. However, when the data is loaded against changes brought about by the 2010 bylaw restrictions, we see that if recreational fishing had continued at the reported rate, 60% of fishers gathering cockles and 12% of fishers collecting *pāua* would likely exceed daily catch limits. The relatively low reported catch rates per person for most species, particularly finfish species, may indicate either i) good compliance or ii) a severe lack of fish, thus prohibiting fishers from catching near the compliance limit. Should this be the case, daily catch limits for some finfish species would need to be reduced in order to remain sustainable.

The most common recreational fishing methods included hand gathering from shore and using a rod / line from a boat. Respondents of the surveys were typically male (74%) who were mostly aged between 45-54 years old. Most fishers (70%) were locals residing within 25km of the taiāpure, although 18% of

fishers travelled from over 200km away. While the majority of recreational fishers were of New Zealand European decent, Māori comprised almost a quarter of those surveyed, a proportion significantly greater than that living in the Otago region and / or New Zealand as a whole. The proportionally high representation of Māori fishers may be a reflection of the cultural and customary significance of gathering *kai moana* (sea food).

A year worth of observation surveys overlooking Karitāne boat ramp revealed a relationship between certain environmental conditions with recreational fishing activity. Wind direction in particular played an overarching role in determining fishing activity, with S, SW and SE winds all deterring fishing activity. Other factors typical of exposed coastlines, including swell, sea state, weather, wind direction, wind strength and water clarity, also affected recreational fishing activity. These findings suggest that the fishery is protected from recreational fishing by unfavorable conditions up to 50% of the year.

This study underscores the widespread use of the East Otago Taiāpure as a recreational and customary fishing hot-spot. The survey methods developed in this study are now available for longer term investigations of sustainability, and help test whether recent bylaw changes have altered fishing success and will trigger restoration of stocks.

Assessment of finfish catches suggest that current daily catch limits will have limited influence on current population trajectories. *Kaitiaki* (environmental guardians) will need to monitor and decide whether further restrictions are needed. However, more baseline data of species population estimates would greatly enhance investigations of catch limit sustainability, allowing for recreational catch data to be put into perspective. In the meantime, *kaitiaki* may choose to manage conservatively and remain aware of the uncertainty over whether recreationally important fishing stocks are likely to be sustained.

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1 Introduction

Taiāpure and *mātaitai* are emerging as the main tools through which *Tangata Whenua* (people of the land) can exercise *kaitiakitanga* (guardianship) and traditional management of customary fishing grounds. There are several new applications for *mātaitai* being processed by the Ministry for Primary Industries (formerly the Ministry of Fisheries) and many more are expected in both freshwater, estuaries and coastal areas in the coming decade. *Mātaitai* and *taiāpure* are collectively referred to as 'Customary Protection Areas' (CPAs). These estuarine or coastal areas are identified as places of particular importance for customary food gathering and are managed by local *hapū* (sub-tribe) communities on a voluntary basis. Few funds are available nationally for stock assessments, monitoring, and research at sufficiently local scales. A lack of resources to combat the potential threats of overfishing, invasive species, pollution, and climate change, coupled with a perceived lack of shared knowledge about how ecosystems function make successful protection and enhancement of *mahinga kai* (the gathering of customary food, the places where food is gathered and the resources themselves) in CPAs more challenging.

Recreational fishing is now highly developed and has a large global and local following. While pleasure is a key motivation for recreational fishing, income generation and supplementation of food supply are also of great importance (Cooke and Cowx, 2006). Fishing is also of great cultural significance for many Māori and inextricably linked with Māori culture, traditions and identity (Dick *et al*., 2013; Schweikert *et al*., 2013; McCarthy *et al*., 2013; Hepburn *et al*., in prep). Ensuring the sustainability of recreational fishing assists the conservation of *mahinga kai* and promotes ecosystem management. Recreational fishers may pose risks to the marine environment in the form of overfishing and poaching beyond set catch limits (Gigliotti and Taylor, 1990; Hepburn *et al*., in prep). According to Gartside *et al*. (1999), recreational catch has not been recorded in the same way as commercial, so detecting historical trends is almost impossible. However, much is at stake in the marine recreational fishery sector of New

Zealand (Kerr *et al*. 2003). For example, the recreational harvest of blue cod (in fisheries management area 7) has been estimated to be "more than ten times the reported commercial harvest". Annual recreational fishing expenditures on the five most commonly caught species exceed $970 million and results in net benefits from fishing in a sum of $220 million annually.

In order to best set management priorities, managers would greatly benefit from a supply of information determining what species are taken, their size, frequency of harvest and amount harvested. This would accordingly indicate which fish are most important to fishers in the area. Additionally, scaling the number of fish caught against the local catch limits would inform managers whether their regulations and rules are actually curtailing the fishing pressure in any way. If fishers seldom reach the catch limit, the rules are having little effect on offtake. These comparisons would begin an assessment of whether existing management is effective, and if not, how it might be modified to ensure sustainability of a resource. In 2010 the East Otago Taiāpure implemented a regulation restricting the legal daily take of certain shellfish species. Investigations of the current and ongoing take of recreational fishers within the *taiāpure* are therefore essential to understanding the effectiveness of the regulation. This report goes a step in that direction by reporting the conditions leading up to the regulation.

Understanding and managing a fishery requires much more information than fish stocks and offtake data alone. Fishery systems are a combination of biological, social, economic, environmental and regulatory mechanisms. Fisheries management may be defined (Lackey, 1998, p330) as "the practice of analysing and selecting options to maintain or alter the structure, dynamics and interactions of habitat, aquatic biota, and man to achieve human goals and objectives". In order to maintain or alter a marine environment, an inventory must be undertaken to see how the social-ecological system is responding to threats and management of the area. The best design of this type of survey can be found by collaboration with the local managers, fishers and scientists. As Lackey (1998) points out, "biological and social science must be better linked if public decision making is going to effectively use what fisheries scientists and

others have to offer". Similarly, Turner (2000, p.459) emphasises the importance of "modelling key environmental and socio-economic processes" in order to properly manage coastal areas. Turner (2000, p.459) also states "there is no substitute for regular contact between researchers from different disciplines in the context of a common research problem and a joint learning curve". The surveys described here combines ecology, sociology, and management by incorporating the knowledge of local fishers.

Researching cultural and social values of recreational fishers, while also investigating spatial and temporal differences in recreational fishing practices will help managers understand the recreational fisher and their environmental impact (Tzanatos et al. 2006). The more the *kaitiaki* (environmental guardians) understand the potential ecological and political interactions among commercial, recreational and customary users, the more empowered they will be to exercise effective *kaitiakitanga* in the customary fishing reserves.

The type of bottom-up community-led management of a fishery promoted by *mātaitai* and *taiāpure* is fundamentally dependent on the knowledge and good will of fishers in the area. An understanding of who the local fishers are, their fishing habits, their level of knowledge of fishing rules and their concerns and support of CPAs are integral to assessing the effectiveness of local scale management. Further, there are often strident debates over who is taking the most from a managed area (commercial, recreational or customary). Data helps elucidate how and the degree to which each group uses the area.

Most often fishing surveys are conducted over a short period (usually a year) so they only give a snapshot of the recreational fisheries. However, if continued over several years, a more complete picture becomes clear and trends can be detected. This study was commissioned by Te Rūnanga o Ngāi Tahu to develop a fishing survey tool for CPA managers to assess fishing pressure, trends in catch success, effects of new CPA fishing rules, levels of compliance and awareness of fishing rules by the reserve users. The research is part of a wider project called Te Tiaki Mahinga Kai; an emerging national network of CPA *kaitiaki*, managers

and researchers dedicated to "*sustained enhancement of the cultural, economic, social and environmental well being of Māori and New Zealand as a whole through the application of mātauranga and science associated with mahinga kai to modern customary fisheries practices*" (See www.mahingakai.org.nz). Te Tiaki Mahinga Kai aims to combine efforts between CPA management groups and instigate a long-term monitoring programme to detect trends and national indicators of sustainability of inshore recreational and customary fishing.

1.1 Objectives

The principal objective of this project is to develop and utilize a study protocol that can be applied by *Tangata Tiaki/Kaitiaki* for the East Otago Taiāpure to estimate:

- The quantity, size and distribution of fish and shellfish being recreationally harvested in each fishing expedition over a complete year;
- The different recreational fishing methods used and their frequency of use;
- The proportion of fish caught and released by recreational fishers;
- The level of compliance of recreational fishers with CPA fishing rules;
- The population profile of the fishers: where they come from, their awareness of the CPA management rules and their perceptions of how fish stocks and fishing practices have changed in the East Otago Taiāpure in recent decades.

2 Methods

2.1 Study area

The East Otago Taiāpure is located north of Dunedin, and encompasses all marine and estuarine waters between Cornish Head (Ohineamio) and Potato Point (Waiweke). It covers an area of 22 km^2 and includes the estuarine inlets of Purakaunui Inlet and Blueskin Bay (Figure 1). The *taiāpure* was established in 1999 and is managed by a Management Committee made up of representatives from Kati Huirapa Runaka ki Puketeraki, Karitāne Commercial Fisherman's Cooperative, the East Otago Boating Club, University of Otago and the River-Estuary Care: Waikouati-Karitāne. The objectives of the East Otago Taiāpure are to ensure customary, recreational and commercial fishers have access to and use of abundant supplies of fisheries resources; to actively promote the use of traditional *tikanga* (customs and lore) and *kawa* (customary practices and protocols) such as *rāhui* (temporary restrictions) through the management of regulations for the *taiāpure*; and to ensure that the adverse impacts of human activities on the marine environment, nursery areas, spawning grounds fisheries habitat and associated dependent species are avoided or mitigated; and to ensure all resources from the *taiāpure* are fit for human consumption (www.fish.govt.nz).

Figure 1. East Otago Taiāpure

2.2 Intercept surveys

Trip records were developed to describe catch, catch effort and the spatial distribution of fishing effort. Trip records were gathered by intercepting fishers landing at wharves and slipways within the East Otago Taiāpure. All incoming boats were approached, but only the ones that had been actively fishing or attempted fishing were asked to take part in the survey. Fishers were asked a series of short questions regarding areas fished, species caught, fishing method used, number age and gender of people on board, time spent fishing, the number and species of fish and shellfish caught, gathered, released or killed. The intercept survey also covered place of residence and reason for fishing. Where possible, the catch was measured and weighed, but often the fish had already been filleted. Within the surrounding area of the East Otago Taiāpure, the main landing sites were the Karitāne boat ramp, Warrington Beach, Blueskin Bay, Doctor's Point, Purakaunui Inlet, Purakaunui boat ramp and the Huriawa Peninsula. The survey was undertaken up to 4 days a week and as frequently as possible from January 2009 to January 2010.

2.3 Fishing observations

In addition to the intercept surveys, sightings of any possible fishing activity were conducted from set points. An observation point overlooking the Karitāne boat ramp served as the main fishing observation location (Figure 2). During each observation the number of boat trailers on site were counted, and used as an approximation for recreational fishing activity in the area. Observations were made once a day and as frequently as possible over a 12 month period. A number of environmental observations were also recorded and included observations of swell conditions, sea state, weather conditions, approximate wind speed, wind direction, water clarity and time of observation. These observations were detailed for the purpose of developing a model to predict fishing pressure in the area, given certain climatic and temporal conditions. No formal instrumentation was used to measure environmental conditions (with the exception of time and wind direction). Instead, observations were made by a small group of observers who underwent a thorough consensus process of classifying each observation. Most fishing observations at Karitāne boat ramp were conducted by one

individual to help ensure consistency (266 of 322 observations). Fishing observations were conducted on site most days of each week over an 18 month time frame.

Figure 2. Observations of recreation fishing activity and environmental conditions were made at Karitāne boat ramp over the course of 18 months. Source: google maps.

2.4 Perception Surveys

To ascertain how people perceive the fishery and changes over the years, key people amongst the local community were identified and interviewed. Interviewees were typically regular community members who regularly fish and have fished in the area for a number of years. The survey consisted of a number of questions and was designed to gather local knowledge concerning the state of local fish stocks, local awareness of the *taiāpure*, its purpose and regulations, and to learn what people want to see happen to fisheries management within the

East Otago Taiāpure. Unfortunately we received only 5 completed perception survey responses, and therefore this section was removed from analysis.

3 Results

3.1 Intercept surveys

3.1.1 Overview; catch within versus outside the *taiāpure*

The majority of recreational fishers intercepted, fished within the *taiāpure*. Precisely three quarters of intercept survey responses[1] reported fishing activity within the *taiāpure*. Four fifths of those who fished within the *taiāpure* targeted shellfish over finfish, while all fishers travelling outside of the *taiāpure* targeted only finfish species (Figure 3).

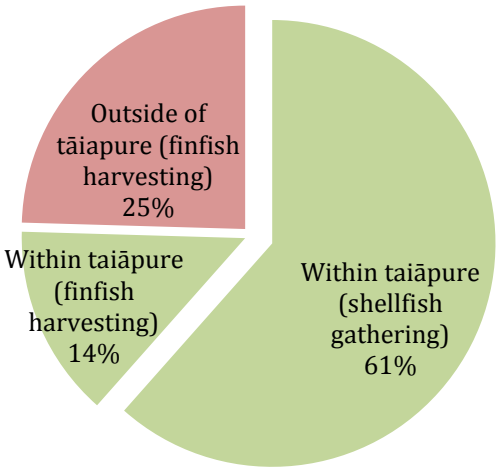


Figure 3. Percentage of recreational fishing activity occurring within and outside the taiāpure, as determined by intercept surveys. N = 273 intercept survey responses.

Overview of total finfish catches within and outside the taiāpure

Finfish was primarily caught outside of the *taiāpure*. Of the 105 intercept survey responses reporting finfish catches, 67 reported catches outside of the *taiāpure* versus 38 within. However the average finfish catch per person was slightly higher for fishers within the *taiāpure* (5.8 fish per person) than outside (4.9 fish per person). Catch Per Unit Effort (CPUE) was also considerably greater within

[1] A total of 273 survey responses were analysed. Each survey response represented one fishing trip or fishing vessel and usually involved more than one person.

the *taiāpure* with fishers catching over twice as many finfish per hour than those fishing outside the *taiāpure*, although much of the difference may be attributed to greater travel times for those venturing outside the *taiāpure*. Fishing groups that ventured outside the *taiāpure* were slightly larger than those fishing within (Table 1).

Table 1. Overview of total finfish catch numbers within and outside the *taiāpure*.

	Within the *taiāpure*	**Outside of *taiāpure***
Total survey responses	38	67
Total individual fishers (harvesting finfish)	89	212
Total finfish catch (all species)	516	1039
Average finfish catch/person	5.8	4.9
Average fishing time per person (minutes)	87.1	181.6
Average finfish catch/person/hour (CPUE)	3.99	1.62
Average number of people per fishing trip	2.3	3.3

3.1.2 Catch within the *taiāpure*

Species caught within the taiāpure:

Of the 220 intercept survey responses reporting catches within the *taiāpure*, 168 reported shellfish harvests. Cockles were the most harvested shellfish among fishers, with 43% of respondents harvesting cockles. *Pāua* (black footed abalone) was the second most harvested species with 27% and mussels the third most harvested shellfish with 14% of respondents harvesting mussels (Figure 4).

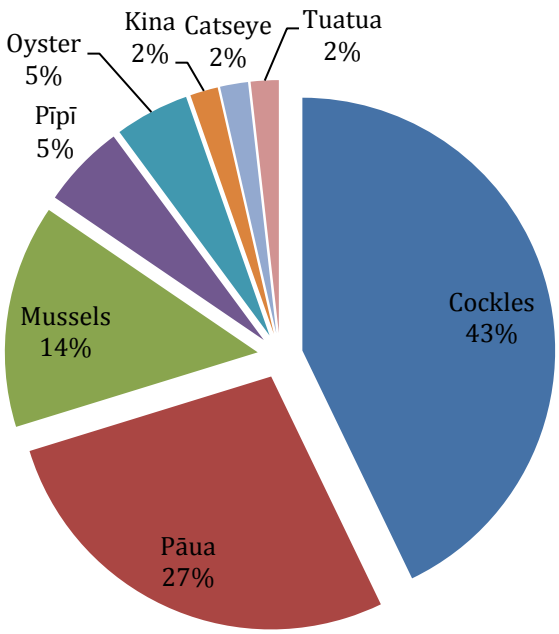


Figure 4. Types of shellfish caught within the *taiāpure*. The numbers on the graph indicate the percentage of total respondents targeting each species. N = 168 survey responses.

Of the 206 intercept survey responses reporting catches within the *taiāpure*, 38 reported finfish harvests. There was a relatively even spread of caught finfish species, with most respondents catching blue cod (21%), followed by greenbone (19%), flounder (13%), Moki (8%) and wrasse (8%) (Figure 5).

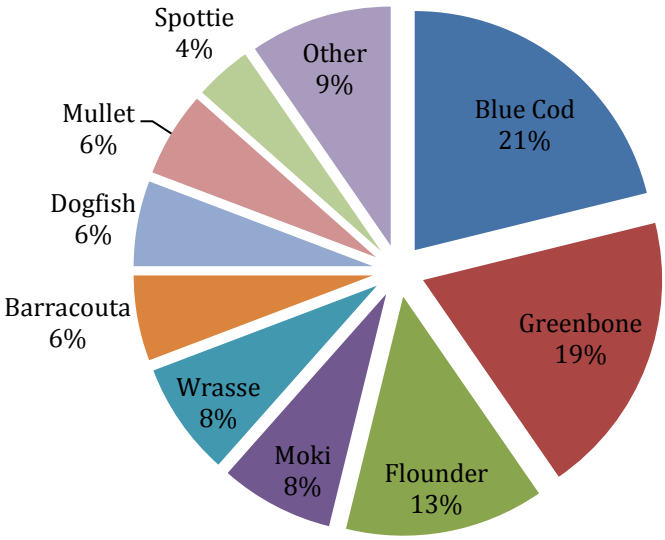


Figure 5. Finfish caught within the *taiāpure*. Numbers on graph indicate the percentage of total respondents targeting each species N = 38 survey responses.

Proportion of catch released:

According to intercept surveys most of the top five harvested shellfish species were kept (Figure 6). While all mussels were kept, a significant proportion of *pāua* (28%) were released. In almost all cases, recreational fishers who released *pāua*, reportedly did so because they were 'too small'.

There was greater variation in the catch and release rate of the top five harvested finfish species, with a greater proportion of blue cod and wrasse released than caught (Figure 7). While blue cod were released according to size, wrasses were released by some fishers on the grounds that they are an undesirable species.

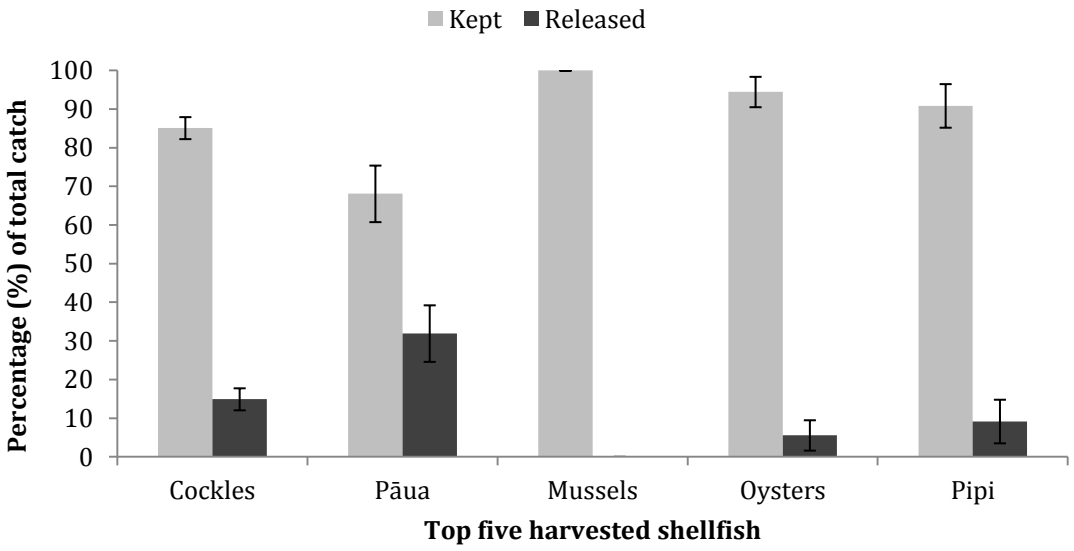


Figure 6. Percentage of kept versus released shellfish for the top five harvested shellfish species within the *taiāpure*. Error bars denote standard error of the means. N = 22671 cockles; 336 *pāua*; 706 mussels; 422 oysters; 309 pīpī.

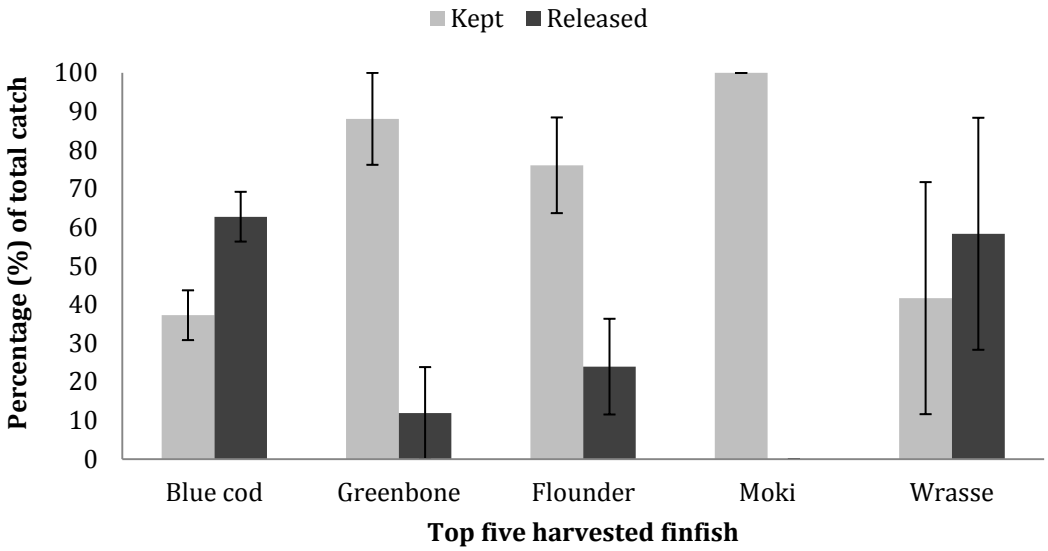


Figure 7. Percentage of kept versus released finfish for the top five harvested finfish species within the *taiāpure*. Error bars denote standard error of the means. N = 198 blue cod; 20 greenbone; 54 flounder; 12 moki; 8 wrasse.

3.1.3 Catch outside of the *taiāpure*

Species caught outside the taiāpure:

Sixty seven intercept survey responses reported fishing in areas outside of the *taiāpure*. These recreational fishers exclusively targeted finfish. Similar to within the *taiāpure*, blue cod was the most caught species, however unlike within the *taiāpure*, blue cod accounted for an enormous 80% of total take. Some species not caught within the *taiāpure* such as jock stewart, trumpeter and parrot fish comprised much of the remaining total finfish take outside the *taiāpure* (Figure 8).

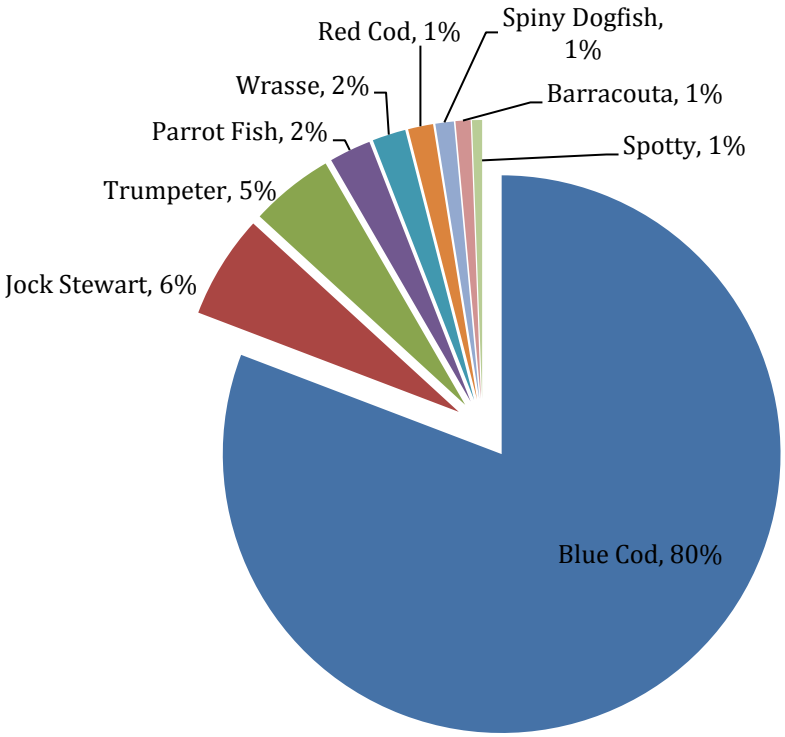


Figure 8. Individual finfish species take as a percentage of total finfish take outside the East Otago Taiāpure. N = 67 survey responses

Proportion of catch released:

According to intercept survey respondents, a large proportion of finfish caught outside the *taiāpure* were released. When analysing the top five harvested finfish we see that 42% of blue cod, 43% of jock stewart and 9 % of trumpeter fish caught were released. For these species, all individuals released were due to them being under the legal size limit. A greater percentage of parrot fish and wrasse were released than kept. While some of the release is attributed to undersized catch, most respondents explain that these species are non-targeted species (Figure 9).

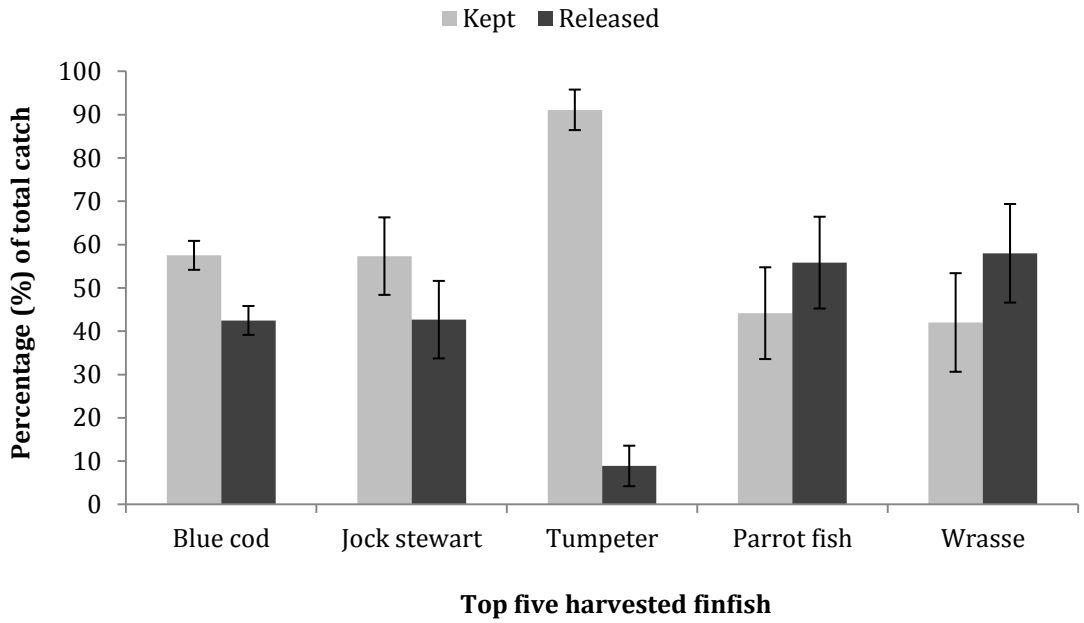


Figure 9. Proportion of kept versus released finfish for the top 5 harvested finfish species outside of the *taiāpure*. N = 1490 blue cod; 133 jock stewart; 58 trumpeter; 62 parrot fish; 101 wrasse.

3.1.4 Legal catch limit compliance

The intercept surveys reported cases of fishers exceeding the daily catch limit for certain species. In the case of shellfish; 60% of cockle gatherers and 11.5% of *pāua* gatherers harvested over the current legal catch limits as implemented by the 2010 East Otago Taiāpure regulation (see Table 2). However, as these figures were obtained immediately before the regulation was implemented, the issue of compliance for these two species is somewhat reduced (see Figures 11 – 12).

The 2010 regulations reduced the daily catch limit of certain species of shellfish and finfish (south of Huriawa) as well as introducing a combined daily catch limit of all shellfish and altering the combined daily limit for finfish species per person (Table 2). Finfish catch compliance was excellent among all main species of interest, with only one case of a fisher exceeding the daily catch limit (based on pre-regulation daily catch limits) (see figures 19 – 27).

Table 2. **Mean take of the most targeted shellfish and finfish species per individual fisher, within and outside the East Otago Taiāpure.** The table also includes percentage of fishers exceeding legal catch limit (relative to pre and post regulation catch limits), minimum legal size limit for each species and theoretical increase in catch due to non compliance (n=222 survey responses). * Regulations were valid from 1st October 2010[2].

Species	Catch limit before regulation*	Catch limit after regulation*	Minimum size (mm)	Mean take per person within *taiāpure*	Mean take per person outside *taiāpure*	% of fishers exceeding regulation* catch limit (within *taiāpure*)	% of fishers exceeding catch limit (outside *taiāpure*)
Shellfish							
Cockles	150	50	None	85.9	-	60	-
Pāua	10	5	125 (ordinary) 80 (yellow foot)	2.9	-	11.5	-
Mussels	50	50	None	14.7	-	5	-
Oysters	50	50	None	21.5	-	0	-
Pīpī	50	50	None	14.6	-	0	-
Combined daily limit: all shellfish	-	50	-	49.2	-	34.4	-
Finfish		(southern taiāpure only)					
Blue Cod	30	10	300	4.6	5.6	22	13
Greenbone	15	10	350	1.3	0.3	0	0
Flounder	30	10	250	2.3	-	0	-
Moki	15	10	400	3.0	-	0	-
Wrasse	30	10	-	1.0	1.4	0	0
Jock Stewart	-	10	-	-	2.0	-	0
Trumpeter	15	10	350	-	1.8	-	0
Parrot fish	-	10	-	-	1.5	-	0
Combined daily limit: all finfish	30	10	-	5.8	4.9	6	0

[2] East Otago Taiāpure regulation was implemented in October 2010, restricting the maximum daily take limit of certain shellfish and finfish species within the taiāpure. New combined daily limits per person for all shellfish species (maximum of 50 shellfish per person) and finfish species (maximum of 10 finfish per person) were also established. The maximum combined daily number of shellfish applies to all shellfish species and includes all crabs, limpets, periwinkles, whelks, barnacles and freshwater crayfish (prior to the 2010 regulation, there was no maximum combined daily limit of shellfish). The maximum combined daily number of finfish applies to all finfish species.

Shellfish catch compliance: combined daily bag limit

Shellfish was only recreationally gathered within the *taiāpure*. While the average combined shellfish take (encompassing all shellfish species) per person was slightly below the legal daily bag limit (see Table 2), a significant percentage of recreational fishers (34%) exceeded the combined daily bag limit of 50 shellfish per person. There were a total of 130 cases of individuals exceeding the combined daily bag limit, with the majority of these individuals harvesting between 51-150 shellfish. Three individuals, however, harvested approximately 1300 shellfish between them (433 each).

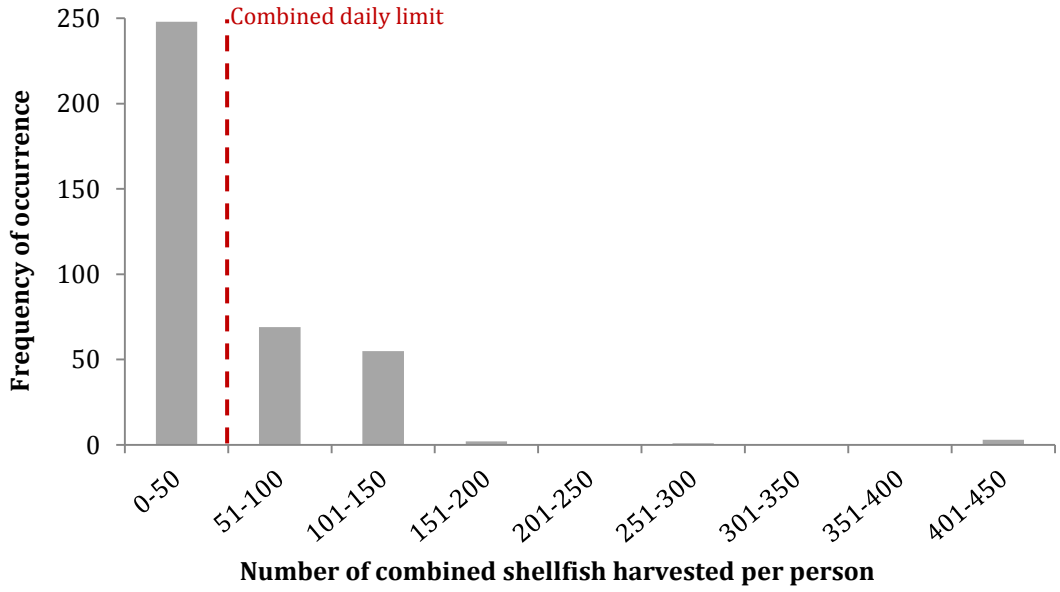


Figure 10. Frequency distribution of combined shellfish take per person. N = 168 surveys.

Shellfish catch compliance: top five harvested species

Figures 11-15 illustrate the distribution of harvest numbers for individual shellfish species and how they compare to daily bag limits. Pre-regulation and regulation catch limits have been inserted into graphs where applicable.

A small proportion of cockle gatherers harvested over the pre-regulation bag limit of 150 cockles per person (Figure 11). Given that all catch figures were recorded prior to the bylaw change we see a relatively good level of compliance,

although three individuals harvested over 400 cockles each. Should, however, cockle harvest levels continue at the current trend, we would see a significant proportion of individuals harvesting above the regulation catch limit of 50 cockles per person. In fact, only 40% of individuals harvested 50 cockles or less.

All *pāua* gatherers harvested below the pre-regulation limit of 10 *pāua* per person, while three individuals harvested above the regulation level of five *pāua* per person (Figure 12). Good compliance was seen for mussel (Figure 13), oyster (Figure 14) and *pīpī* (Figure 15) gathers, with only one individual harvesting above the daily bag limit for cockles. Mussel, oyster and *pīpī* daily bag limits were unaffected by the implementation of the 2010 regulation.

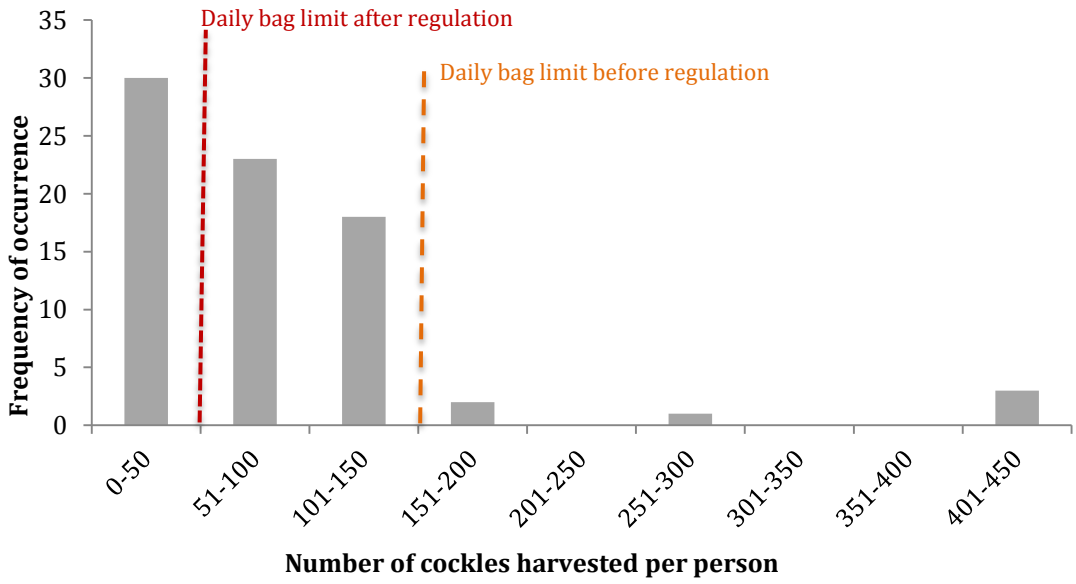


Figure 11. Frequency distribution of cockle take per person. N=75 surveys.

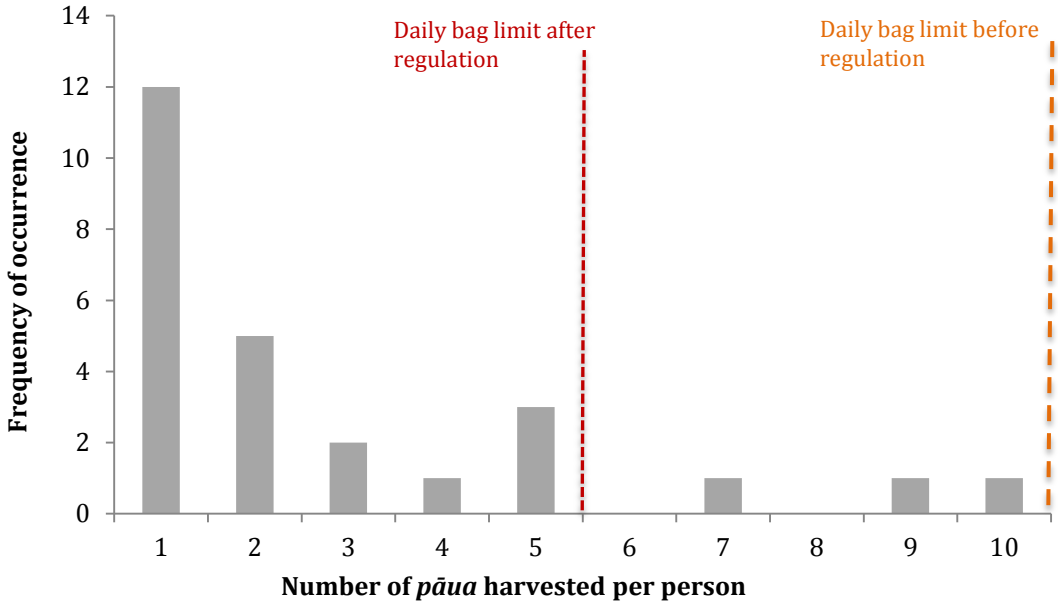


Figure 12. Frequency distribution of *pāua* take per person. N=26 surveys

Figure 13. Frequency distribution of mussel take per person. N=20 surveys

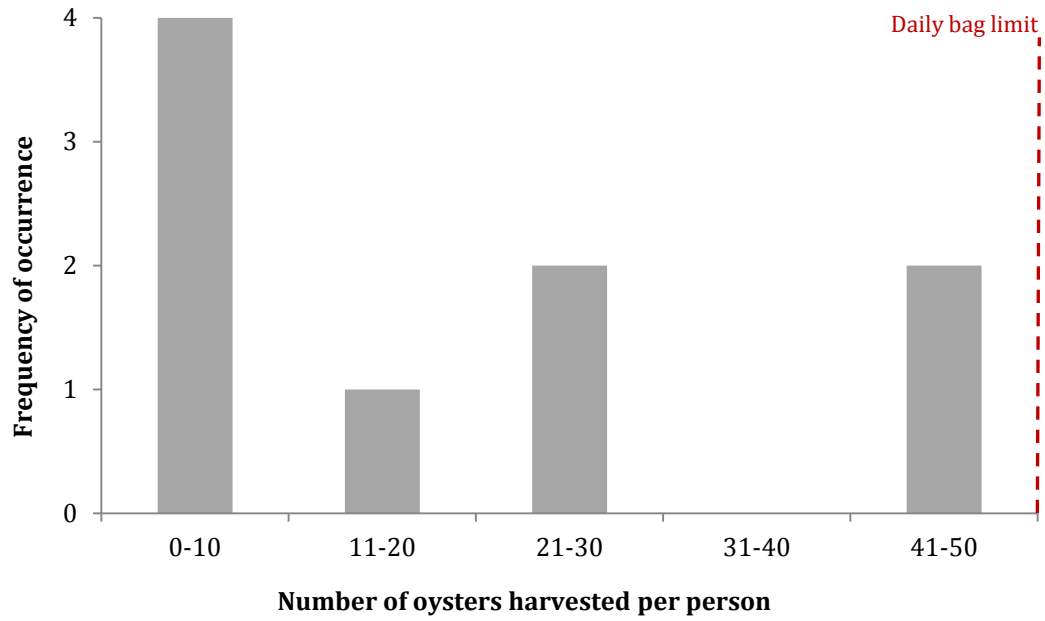


Figure 14. Frequency distribution of oyster take per person. N=9 surveys

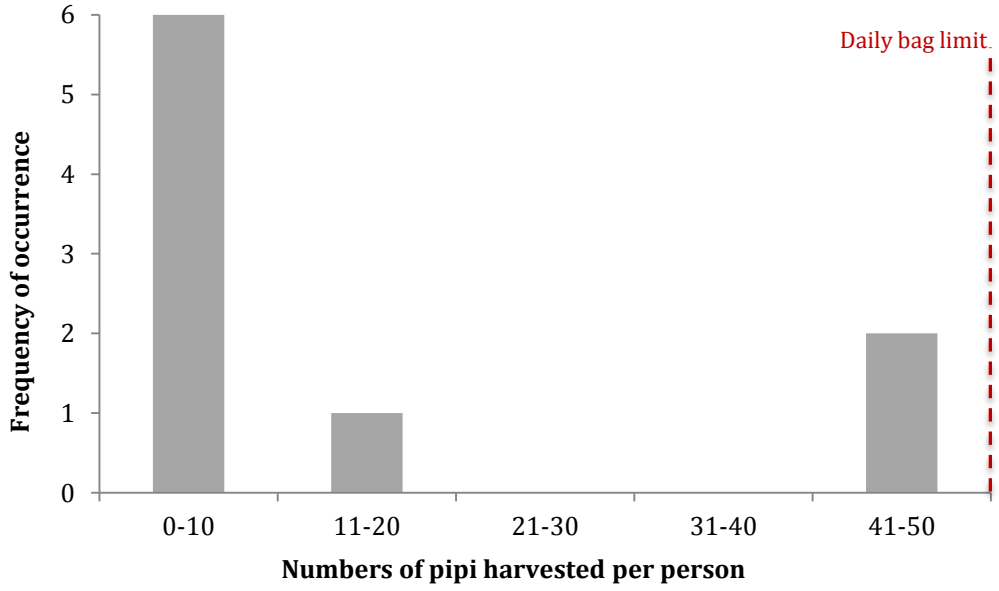


Figure 15. Frequency distribution of *pīpī* take per person. N=9 surveys

Shellfish: level of compliance under different daily bag limit scenarios

Compliance levels were calculated for different theoretical bag limit scenarios by dividing the sum of catch below each theoretical limit by the sum of the total catch: ∑ catch below each theoretical limit / ∑ of total catch. Furthermore, individuals exceeding limits would be assigned the maximum catch value for each theoretical limit (i.e. an individual who harvested eight *pāua* would be assigned a maximum of five *pāua* for a theoretical catch limit of five). Calculations of compliance therefore include all fishers at each theoretical level, and help paint a more complete picture of relative compliance.

The level of compliance for people harvesting *pāua* (based on reported catch numbers) changes under different theoretical bag limits. Figure 16 illustrates 100% compliance in *pāua* take relative to the pre-regulation limit (10 *pāua* per person). The level of compliance steadily drops with decreasing theoretical bag limits; with an 82% compliance at current regulation limits (5 pāua per person).

Reported cockle harvests show 92% compliance at the pre-regulation limit (150 cockles per person) but only 50% compliance at the regulation limit (50 cockles per person) (Figure 17). The daily bag limit for oysters and *pīpī*, of 50 per person, was not exceeded (100% compliance), while mussel harvest numbers show 95% compliance at the current daily bag limit. The level of compliance for all three species steadily drops with decreasing bag limits (Figure 18). Note that the official daily bag limit for these three species was not affected by the 2010 regulation changes.

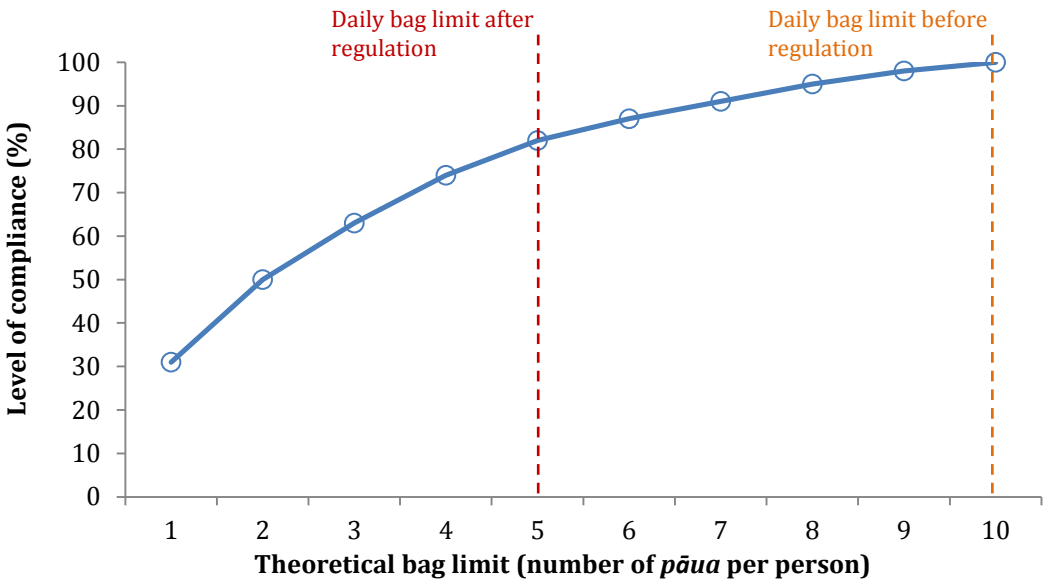


Figure 16. Level of compliance (based on reported catch numbers) under different theoretical legal bag limit scenarios for *pāua*.

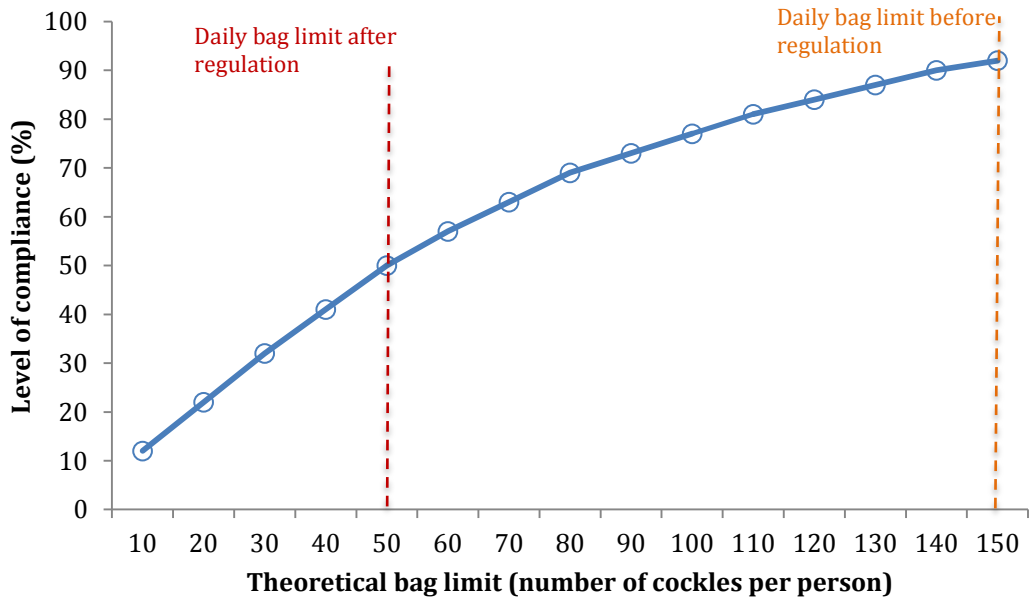


Figure 17. Level of compliance (based on reported catch numbers) under different theoretical bag limit scenarios for cockles.

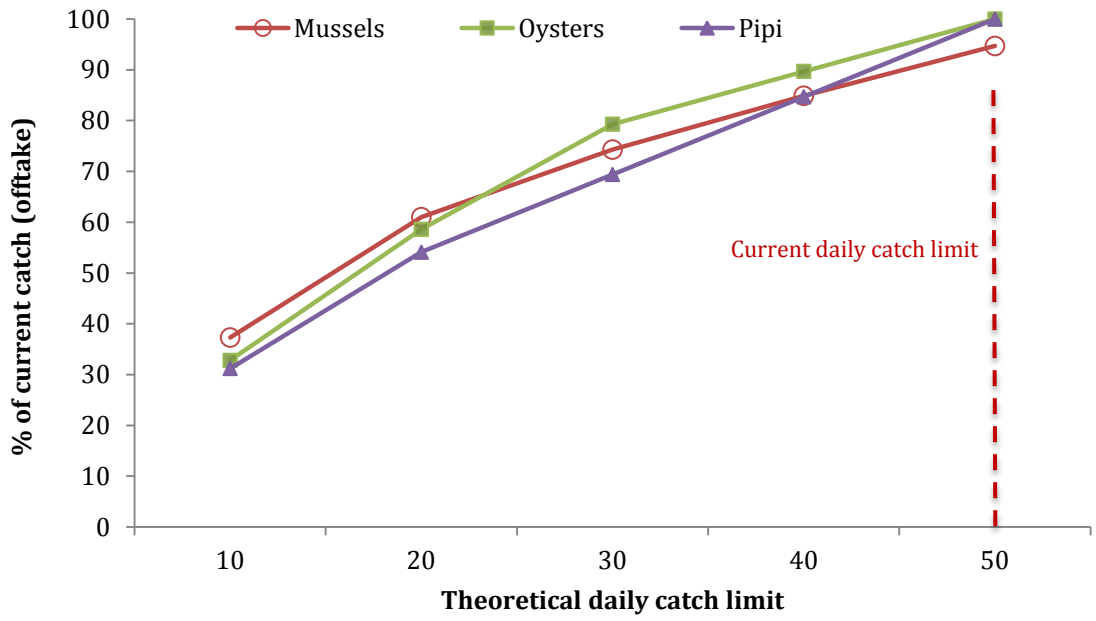


Figure 18. Level of compliance (based on reported catch numbers) under different theoretical legal catch limit scenarios for mussels, oysters and *pīpī*.

Finfish catch compliance: combined daily bag limit

The combined daily catch limit for all finfish species within the *taiāpure* (south of Huriawa) was reduced from 30 fish per person to 10 fish per person in accordance with the 2010 regulation. Outside the *taiāpure* the daily catch limit remained at the pre-regulation level of 30 fish per person. Finfish harvesting was almost four times more prevalent outside the *taiāpure* than inside (Figure 19). Outside the *taiāpure*, there was only one reported case of a fisher exceeding the combined daily limit of 30 fish per person. Numbers within the *taiāpure* show that while five individuals harvested above the regulation limit of 10 fish per person, all fishers within the *taiāpure* caught below the pre-regulation catch limit of 30 fish per person (Figure 19).

Finfish catch compliance: individual species of interest

The five most targeted finfish species both within and outside the *taiāpure* are included in the compliance graphs below (Figures 20 – 27). Excellent finfish

catch compliance was reported for almost every species of interest, with no cases of excess catch reported for greenbone, flounder, moki, wrasse, jock stewart, trumpeter or parrot fish (see Figures 21 – 27). In fact, the daily catch limit was only exceeded for blue cod by one fisher who harvested 40 blue cod outside the *taiāpure*. No fishers fishing within the taiāpure exceeded the pre-regulation catch limit of 30 blue cod per day (Figure 20).

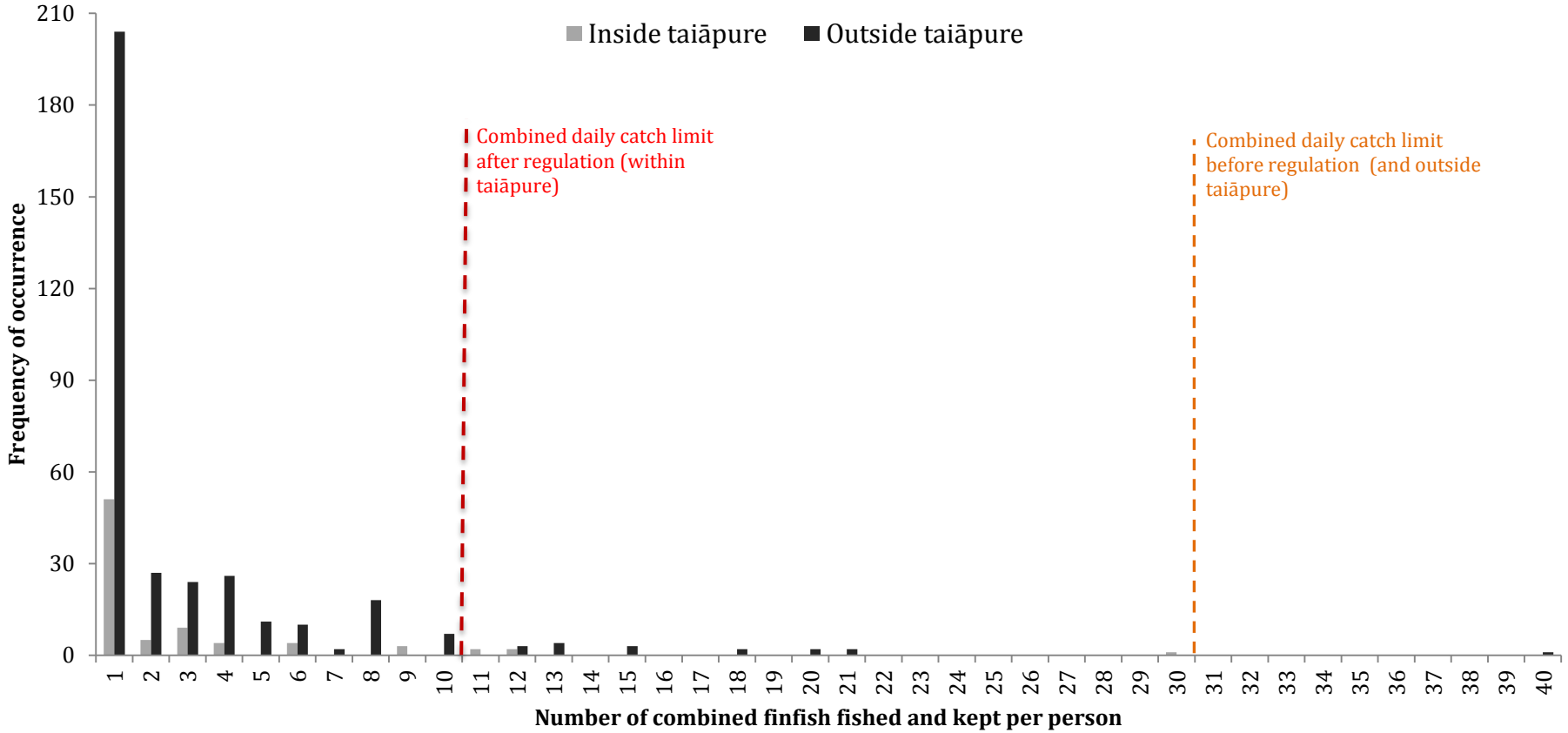


Figure 19. Frequency distribution of combined finfish take per person within and outside the East Otago Taiāpure. N = 89 cases within the *taiāpure* and 346 cases outside the *taiāpure*.

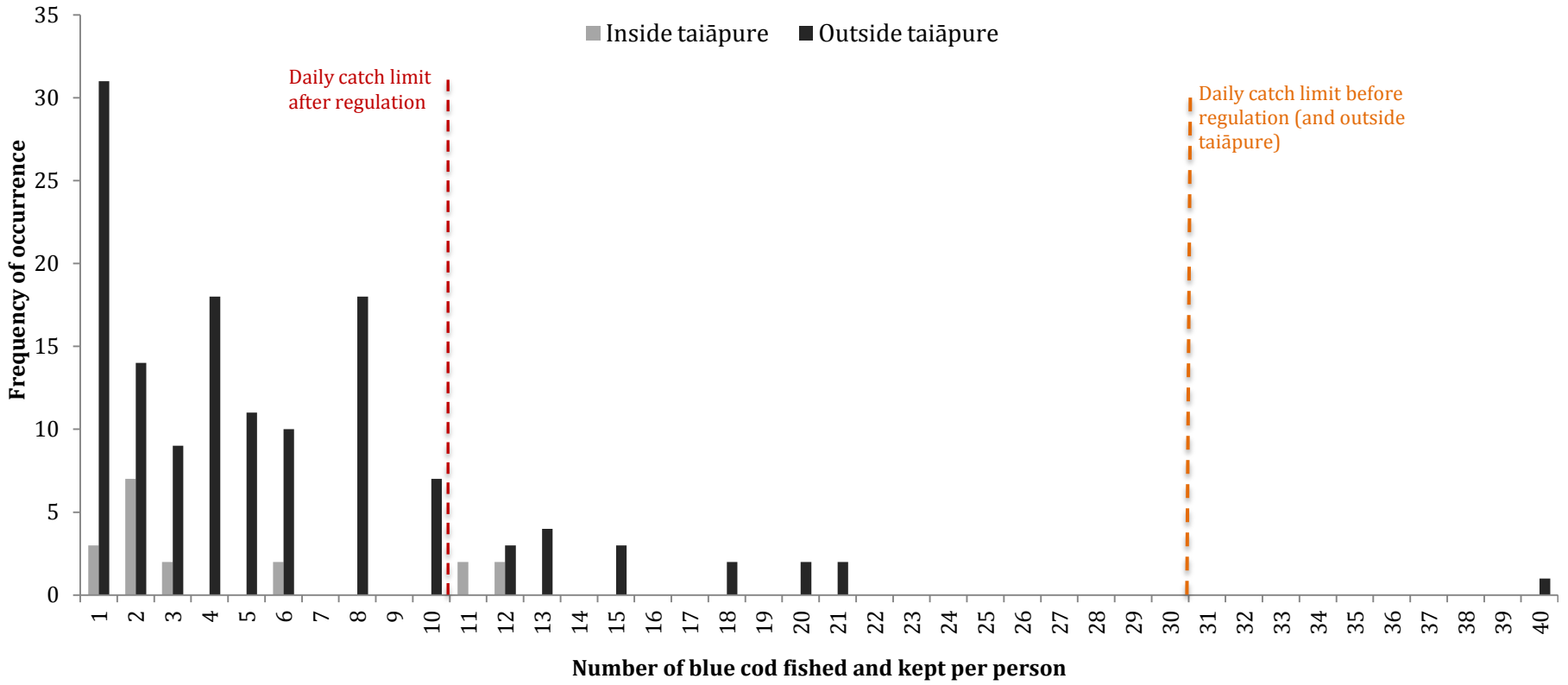


Figure 20. Frequency distribution of blue cod take per person within and outside the East Otago Taiāpure. N=18 fishers within *taiāpure* and 135 fishers outside the *taiāpure*.

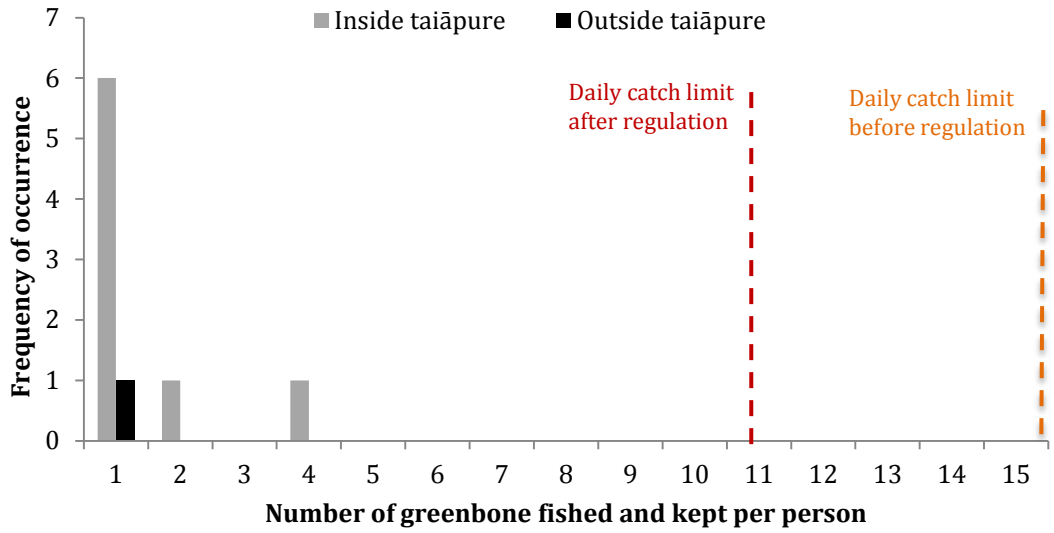


Figure 21. Frequency distribution of greenbone take per person within and outside the East Otago Taiāpure. N = eight fishers within *taiāpure* and one fisher outside the *taiāpure*.

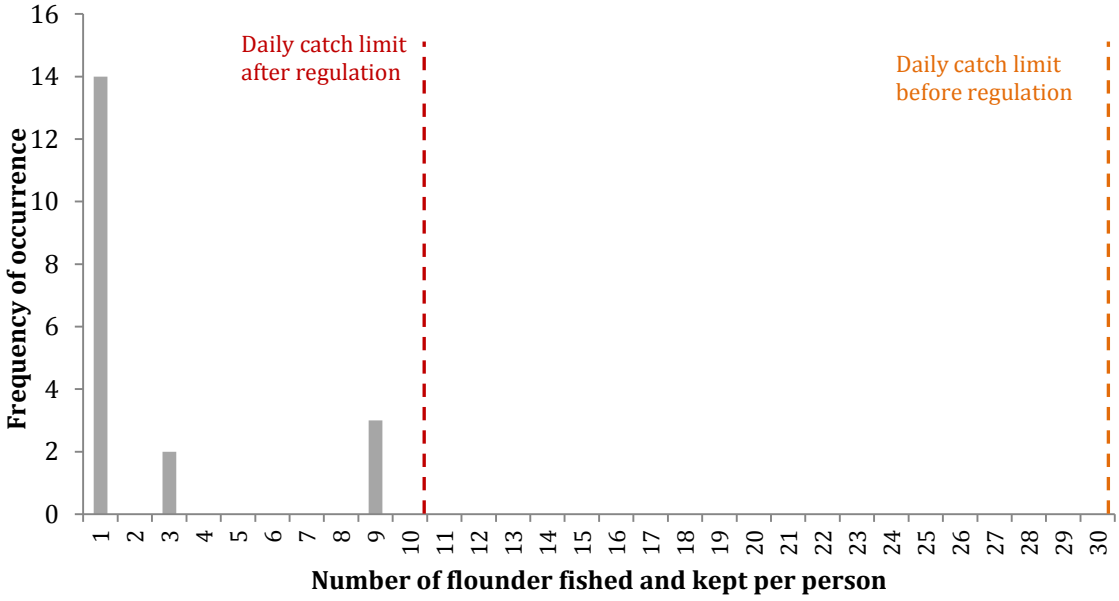


Figure 22. Frequency distribution of flounder take per person within and outside the East Otago Taiāpure. N = 19 fishers within *taiāpure* and zero fishers outside the *taiāpure*.

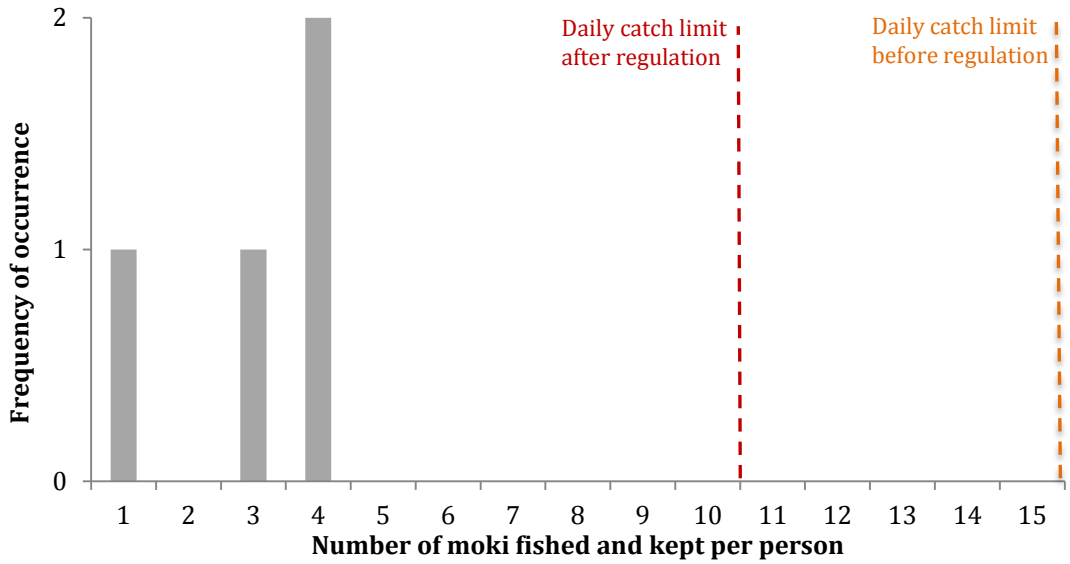


Figure 23. Frequency distribution of moki take per person within and outside the East Otago Taiāpure. N = four fishers within the *taiāpure* and zero fishers outside the *taiāpure*.

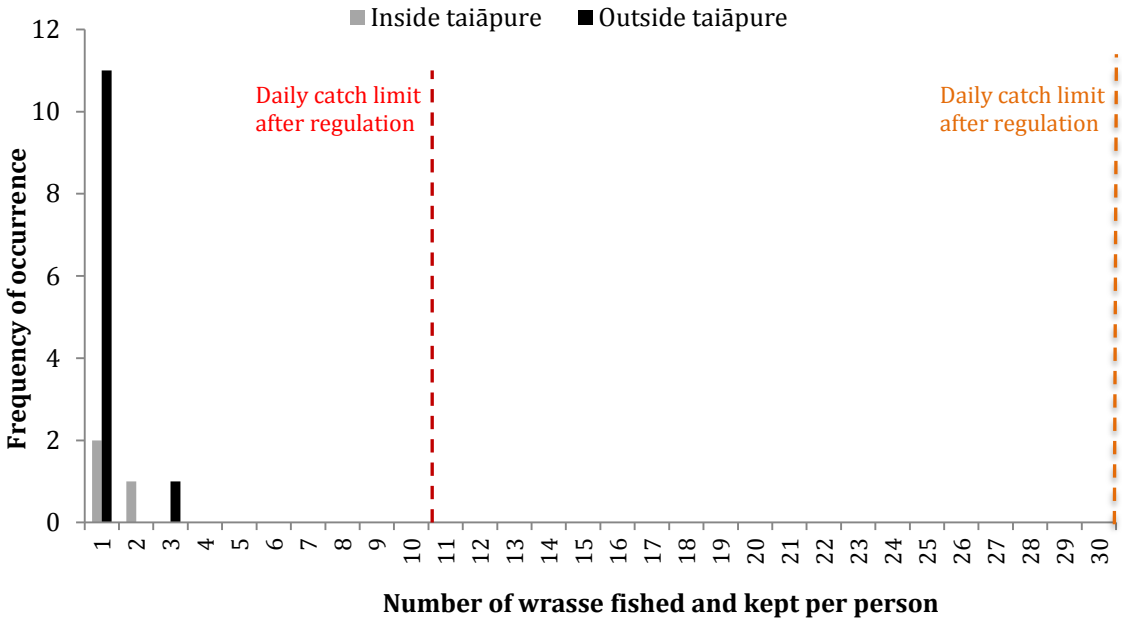


Figure 24. Frequency distribution of wrasse take per person within and outside the East Otago Taiāpure. N = three fishers within the *taiāpure* and 12 fishers outside the *taiāpure*.

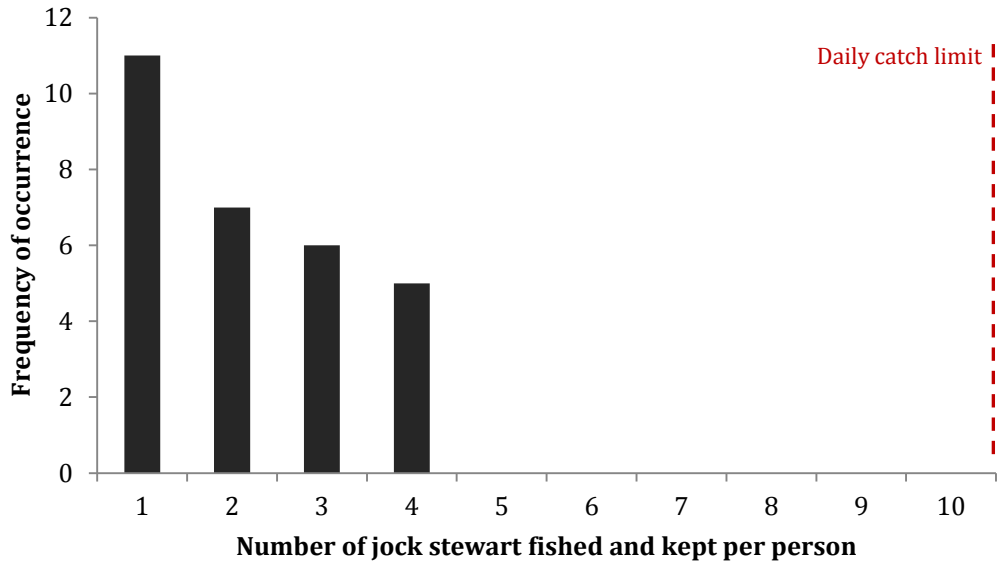


Figure25. Frequency distribution of jock stewart take per person. N = zero fishers within the *taiāpure* and 29 fishers outside the *taiāpure*.

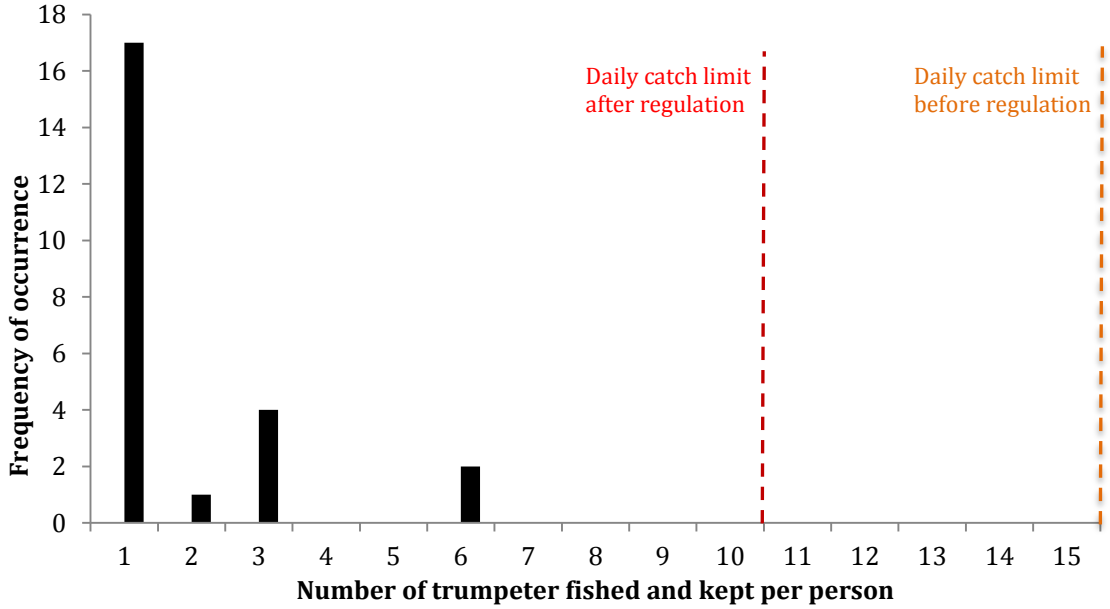


Figure 26. Frequency distribution of trumpeter take per person. N= zero fishers within the *taiāpure* and 24 fishers outside the *taiāpure*.

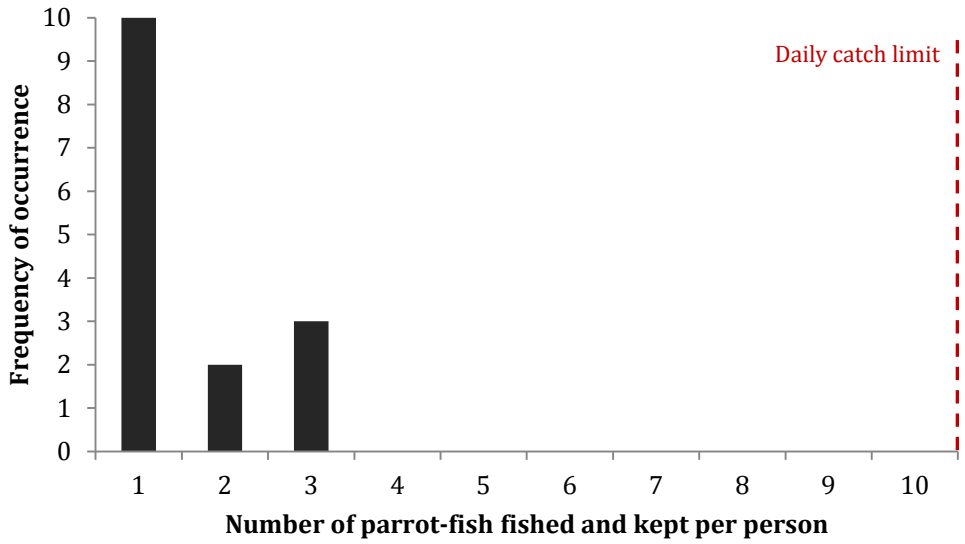


Figure 27. Frequency distribution of parrot fish take per person. N= zero fishers within the *taiāpure* and 24 fishers outside the *taiāpure*.

Finfish: level of compliance under different daily bag limit scenarios

Based on reported catch rates, the level of compliance for people harvesting finfish is generally satisfactory within the *taiāpure*, when compared to the new fishing regulations established in 2010. In fact the theoretical bag limits for greenbone and moki need to be reduced down to three fish per person before any issues of compliance become apparent. The case is even more pronounced for wrasse, with 100% catch compliance occurring down to a theoretical compliance limit of only two fish per person. Flounder shows complete catch compliance down to nine fish per person, but soon tapers off with decreasing theoretical limits. Blue cod is the only finfish species within the *taiāpure* that did not exhibit complete compliance at the newly established regulation of 10 blue cod per person. A theoretical halving of the current catch limit to five fish per person results in only 64% catch compliance for blue cod (Figure 28).

The pattern of compliance is similar outside the *taiāpure*, with all species bar blue cod showing complete compliance at the new regulation limit of 10 fish per person. Blue cod catch compliance is lower outside the *taiāpure* than within, with only 84% catch compliance at the current catch limit. A theoretical halving of the current limit to five fish per day results in 61% catch compliance for blue

cod (Figure 29). Note that lines on the graph representing each species have been slightly staggered (at the 100% compliance level) to allow for visual differentiation of species.

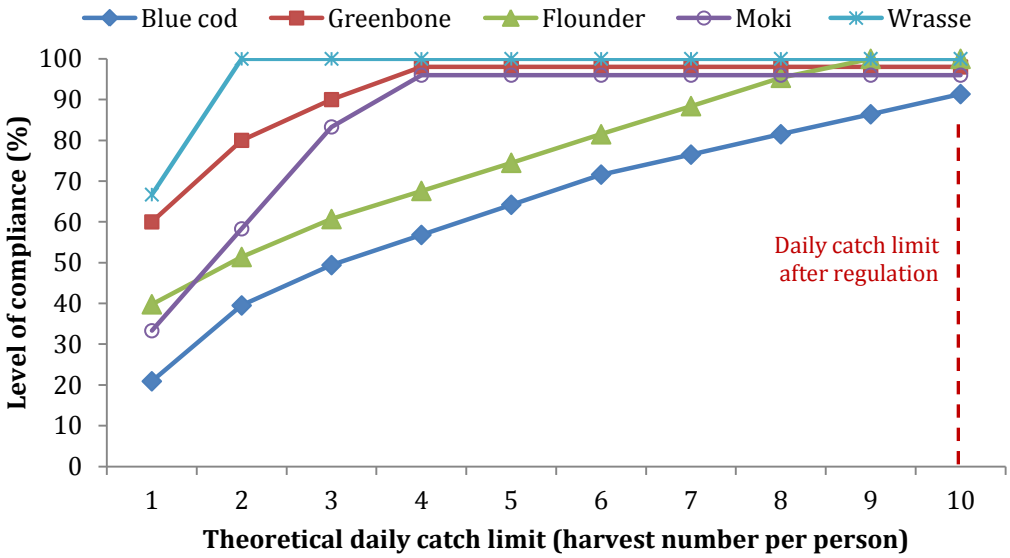


Figure 28. Level of compliance (based on reported catch numbers) under different theoretical legal catch limit scenarios for the top five caught finfish within the *taiāpure*.

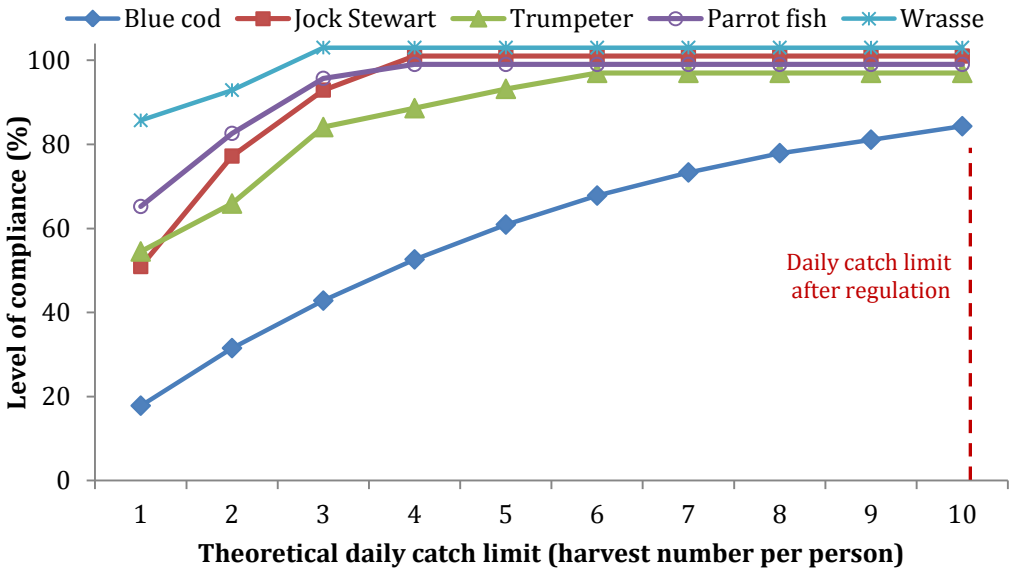


Figure 29. Level of compliance (based on reported catch numbers) under different theoretical legal catch limit scenarios for the top five caught finfish outside the *taiāpure*.

3.1.5 Fishing methods

The most common methods of fishing for all survey respondents were hand gathering from shore and rod/line fishing, collectively representing nearly 80% of all fishing (Figure 30). Hand gathering is a fishing method almost exclusive to shellfish harvesting.

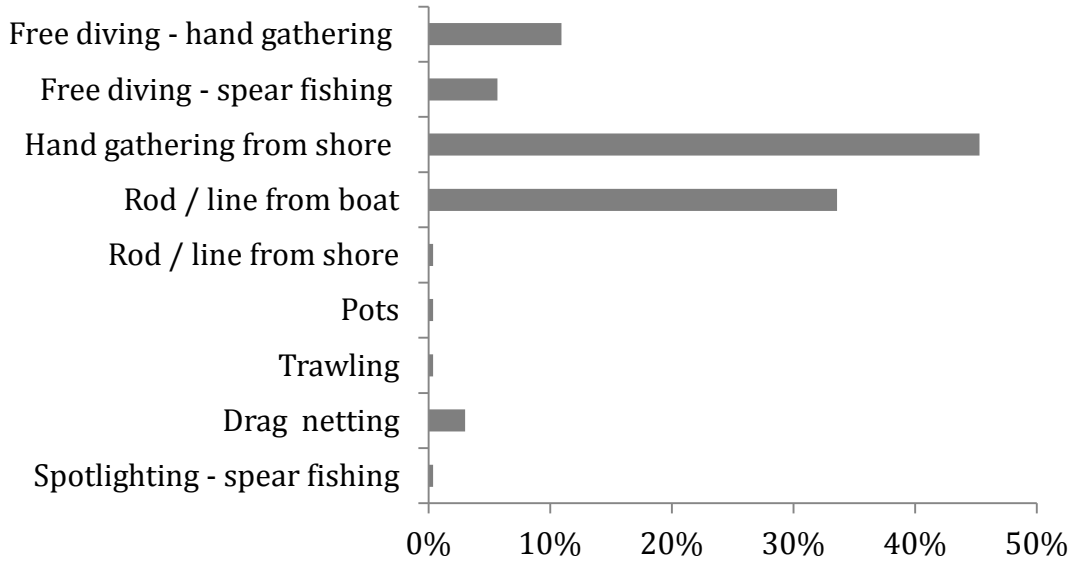


Figure 30. Fishing method of respondents of the East Otago Taiāpure intercept surveys, 2009-10 (n = 265)

3.1.6 Attributes of respondents

Gender and age of respondents:

Of the 517 respondents in total from the East Otago Taiāpure, 74% were male. Female fishers tended to be between the ages of 35-44 (26%), though 12% of female fishers were between 20-24 years of age. The largest age groups of male fishers were slightly older than those for female fishers, as evidenced by a greater number of 45-54 year-old fishers (25%) (Figure 31).

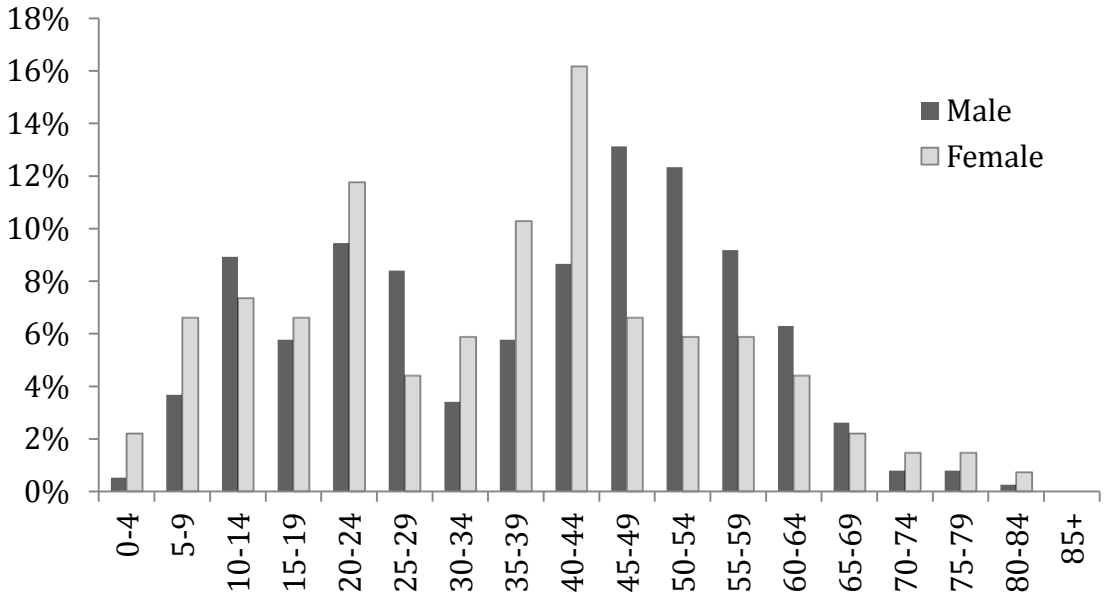


Figure 31. Age distribution for respondents of the East Otago Taiāpure intercept surveys, 2009-10 (n=517 individual respondents)

Ethnicity:

Respondents who chose to reveal their ethnicity predominantly identified themselves as European. Māori comprised the second-largest group, followed by Asian and Pacific peoples. Eight percent of respondents did not specify an ethnicity but instead labeled themselves as 'New Zealanders' (Figure 32).

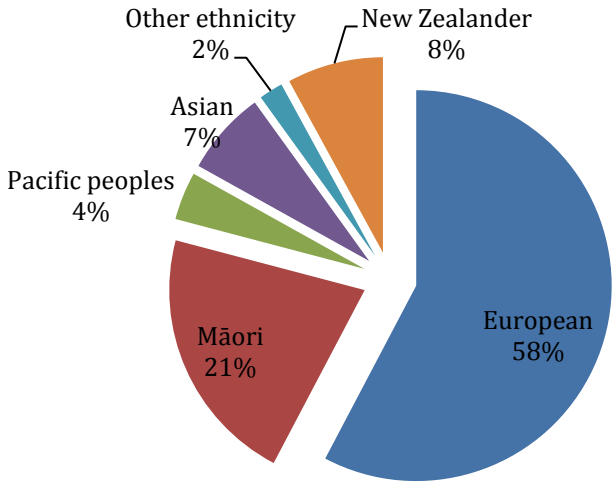


Figure 32. Ethnicity of respondents of the East Otago Taiāpure intercept surveys, 2009-10 (n=201 respondents)

The ethnic composition of recreational fishers in the East Otago Taiāpure is compared with the ethnic composition of recreational fishers of the South Otago Mātaitai (Punawai o Toriki Mātaitai) and general census figures for both the wider Otago region and New Zealand as a whole. We reveal a significantly larger proportion of Māori partaking in recreation fishing in the East Otago Taiāpure than for the South Otago Mātaitai. Additionally, the proportion of East Otago Māori fishers and harvesters is three times greater than the proportion of Māori living in the Otago region and 50% greater than proportion of Māori living in New Zealand as a whole (according the Census 2006 data) (Figure 33).

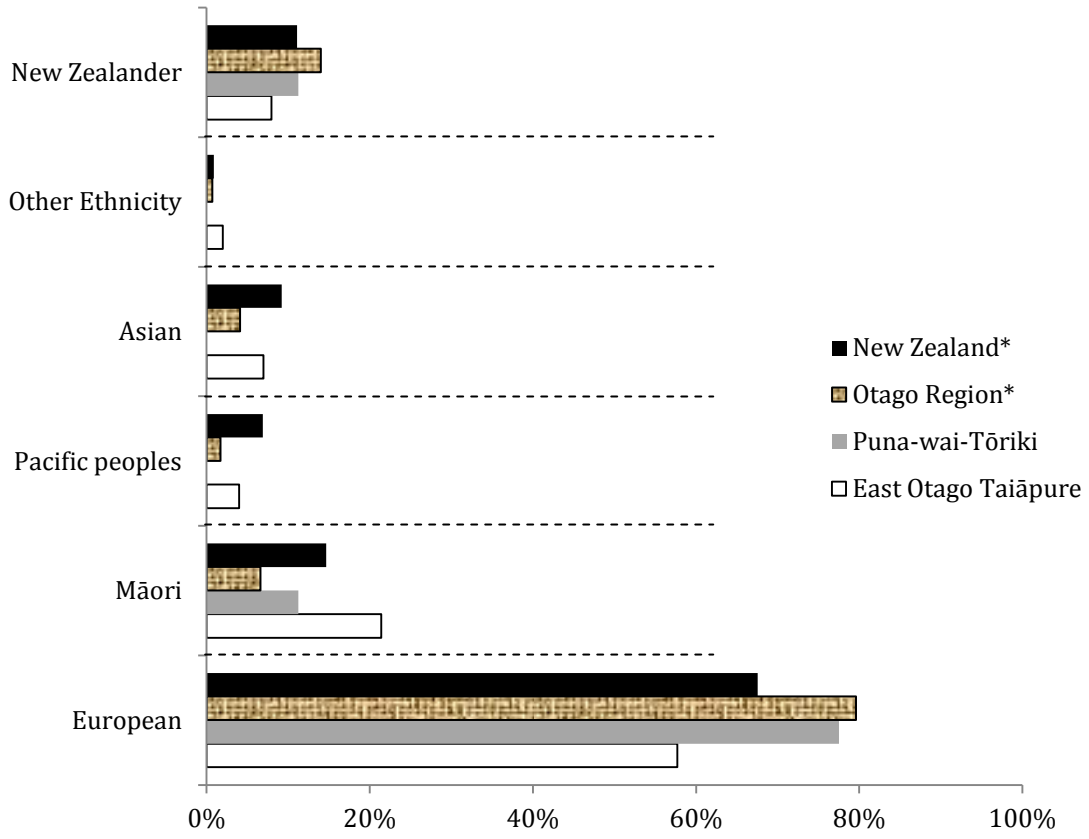


Figure 33. Ethnic composition of the East Otago Taiāpure recreational fisher respondents, Puna-wai Tōriki recreational fisher respondents, the Otago region and New Zealand. *Data according to Census 2006.

Place of origin:

The majority of fishers were from Dunedin or surrounding environs, including Warrington, Karitāne and elsewhere within the Otago region (Figure 34). Most fishers traveled less than 25 kilometers to fish in the *taiāpure*, although 18% of respondents travelled more than 200 kilometers (Figure 35).

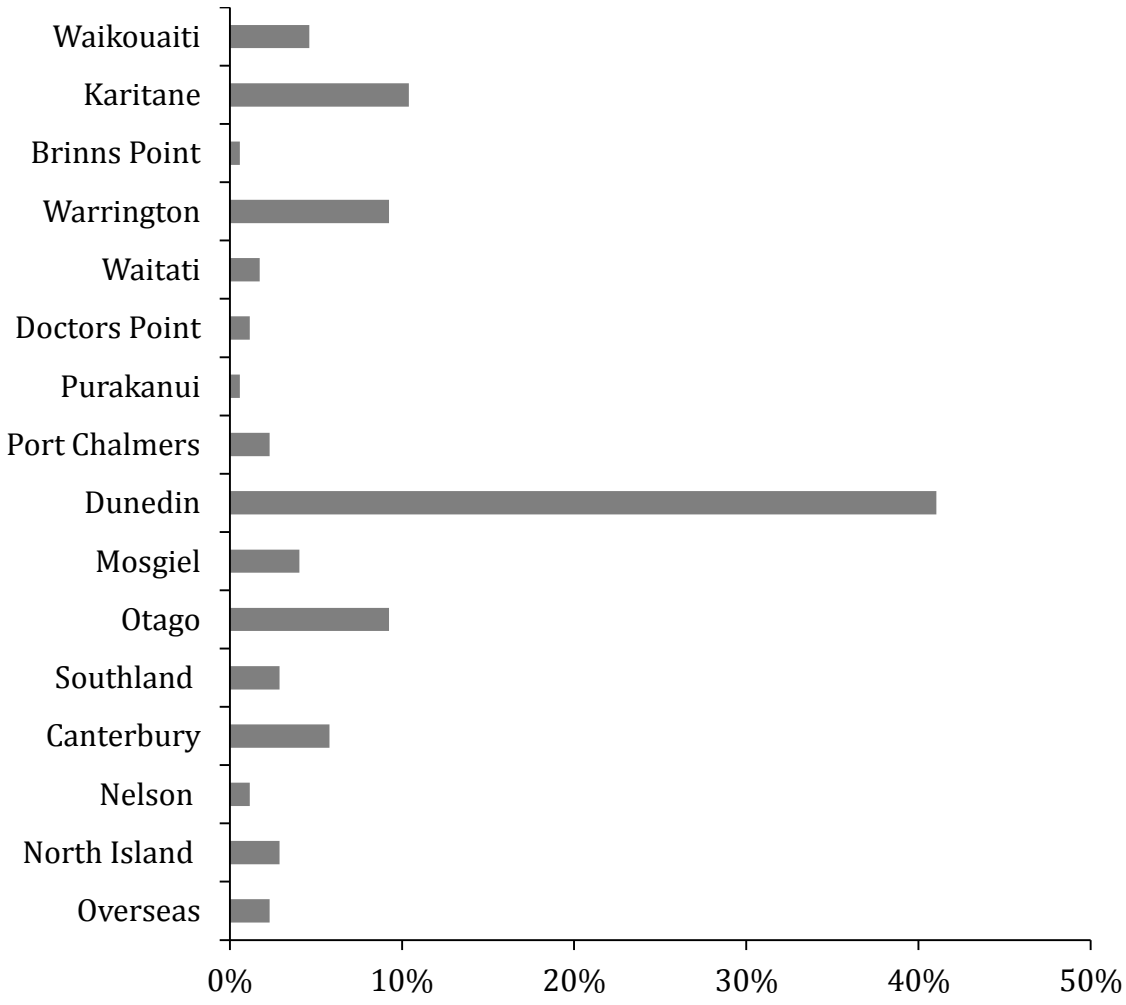


Figure 34. Place of residence for respondents of the East Otago Taiāpure intercept surveys, 2009-10 (n=173)

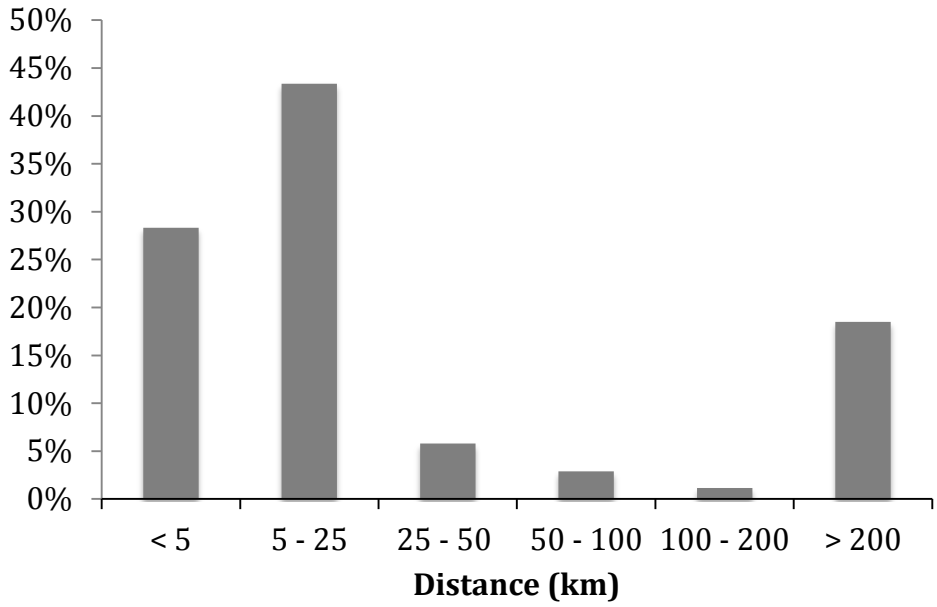


Figure 35. Distance travelled for respondents of the East Otago Taiāpure intercept surveys, 2009-10 (n=173)

3.2 Fishing observations

Fishing observations were conducted from a vantage point overlooking Karitāne boat ramp. Boat trailer counts, used as an approximate method of estimating recreational fishing activity was recorded for most days alongside observations of weather and swell conditions. Figure 36 shows boat trailer counts at Karitāne boat ramp over a 12 month period. Observations were made once a day, and over as many days of the year as possible. A total of 322 observations over the course of 12 months were conducted. Statistically significant differences in the amount of boat trailer counts per month was discovered using a one way ANOVA (F_{282} = 2556.078, p = 0.002), with greatest average trailer counts occurring in January and August and lowest counts occurring in winter months of May and June. A maximum of 34 boat trailers observed on 31st January 2010 coincides with a local fishing competition day (this outlier was removed during statistical analysis) (Figure 36).

Linear models were used to determine whether the number of boat trailer counts at Karitāne was significantly influenced by environmental factors. (Table 3). Particular factors included observations of swell, water clarity, sea state, general weather conditions, wind direction, wind strength and time of day. Significant differences in the number of boat trailer counts were found for water clarity, weather, wind direction, wind strength and time of observation. When all factors are taken into consideration we find that swell and sea state factors did not significantly influence the number of boat trailers at Karitāne during the 12 month observation period, despite the graphical representations of both these factors suggesting otherwise (see Figures 37 and 38). However, analysis of statistical correlations reveals that there are close correlations between wind direction and swell, as well as wind direction and sea state. Since the statistical model probably cannot disentangle these factors accurately, we suggest that both of these factors are indeed important, though they may affect how long people stay out fishing more so than whether people go fishing or not.

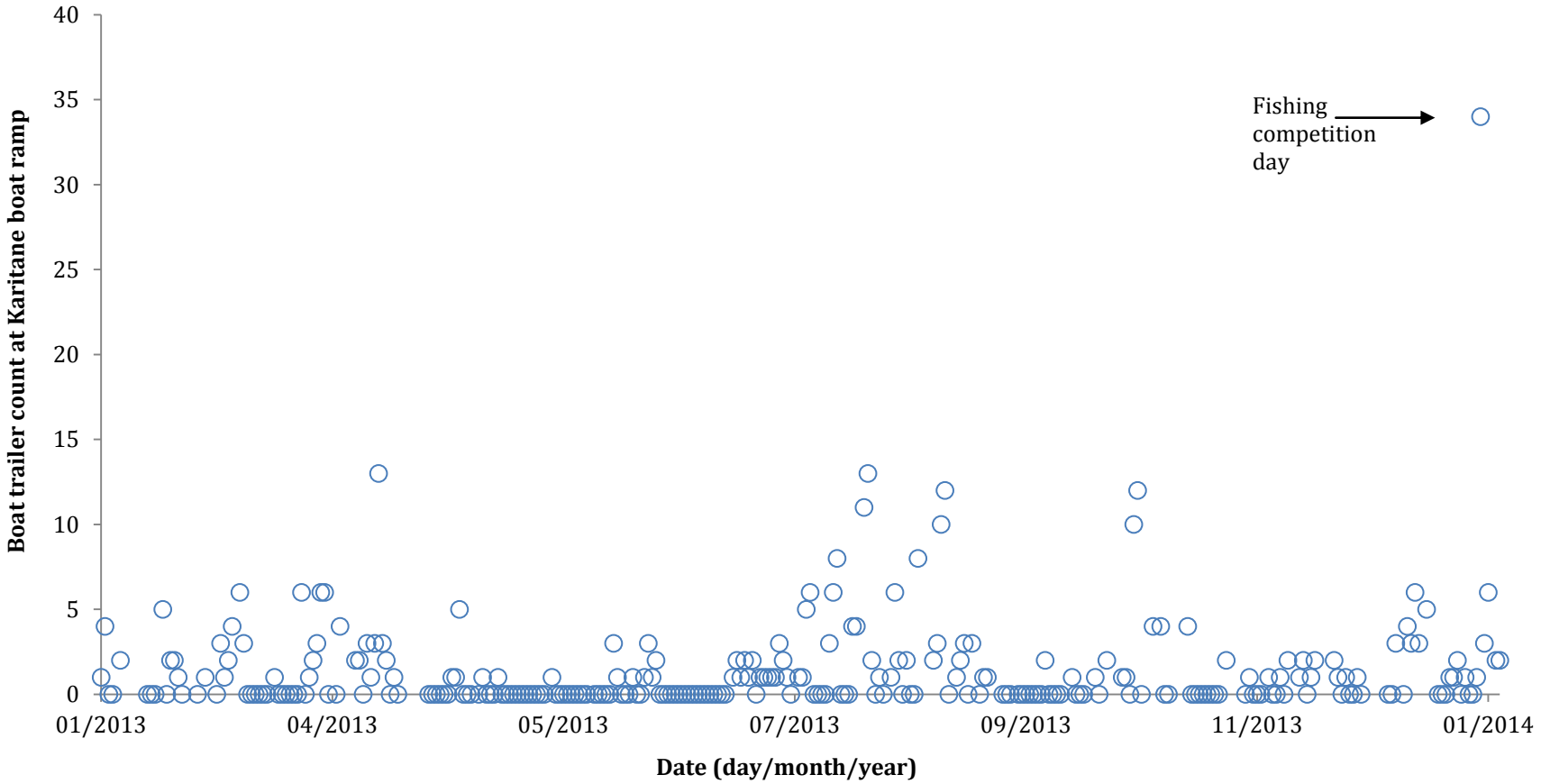


Figure 36. Boat trailer counts at Karitāne recorded over a one year period. A high of 34 boat trailers on the 31st of January 2010 corresponds with a local fishing competition day.

Table 3. **A series of linear models to determine which observed environmental factors significantly influenced boat trailer counts at Karitāne boat ramp.** Note that all observations were made between the hours of 9am and 5pm**.**

Factor	Observation	Number of observations	Is it significant? (P value)
Swell	Large (reference)	83	
	Moderate	70	0.643
	None	17	0.625
	Small	81	0.103
Water clarity	Average (reference)	54	
	Good	71	**0.019**
	Poor	103	0.490
Sea state	Calm (reference)	70	
	Moderate	75	0.262
	Rough	99	0.271
Weather	Overcast (reference)	48	
	Partly Cloudy	48	0.538
	Persistent Rain	32	0.232
	Showers	43	0.420
	Sunny	67	**<.001**
Wind direction	N (reference)	25	
	NE	22	**0.030**
	E	11	0.117
	SE	12	0.133
	S	54	**0.006**
	SW	31	**0.014**
	W	31	**0.017**
	NW	15	0.654
Wind strength	Light (reference)	76	
	Moderate	55	**0.040**
	None	32	0.106
	Strong	73	0.131
Time	Relative to high tide	263	0.782

By examining environmental factor separately, we see that each factor has certain conditions that influence activity (approximated by boat trailer counts) at Karitāne . The data suggest that the larger the swell conditions, the lower the number of boat trailer counts (Figure 37). Likewise, rougher sea state conditions resulted in significantly lower boat trailer counts (Figure 38). Recreational fishing activity is typically greatest during sunny weather conditions (Figure 39), during northerly or easterly winds (Figure 40), and during periods when wind

speed was reportedly 'light' or completely still (Figure 41). A relationship was also found for water clarity, with clearer water conditions harbouring higher recreational fishing activity (Figure 42). No relationship was found between boat trailer counts and hours relative to high tide.

The data show that 'unfavourable' conditions can severely reduce recreational fishing activity at Karitāne , thus acting as a protective mechanism for local fisheries. For each environmental factor we see that the proportion of unfavourable observations is relatively large during the course of a year. According to our observations, conditions deterring recreational fishing activity occurred 33% of the time with regard to swell conditions (large swell); 40% of the time with regard to sea state conditions (rough sea state); 72% of the time with regard to weather conditions (partly cloudy, overcast, showers, persistent rain); 48% of the time with regard to wind direction (S, SE, SW winds); 54% of the time with regard to wind strength (moderate, strong winds); and 45% of the time with regard to water clarity (poor visibility). This suggests that weather severely restricts fishing at Karitāne for around 50% of the time.

Swell conditions:

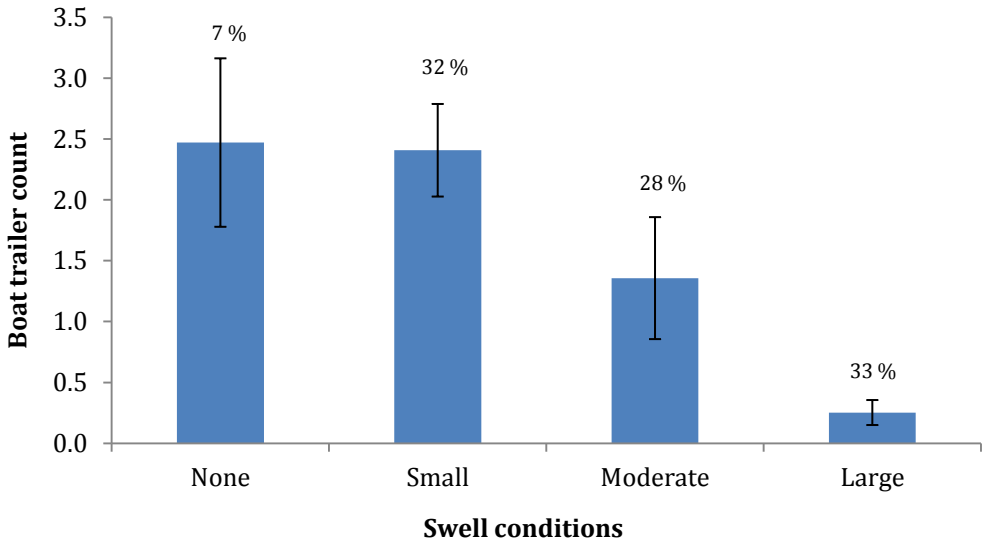


Figure 37. Boat trailer counts at Karitāne during different swell conditions. Error bars denote standard error of the means. Numbers above error bars represent the percentage of total observations for each swell condition. Actual observation counts = 17 for 'none'; 81 for 'small'; 70 for 'moderate'; 83 for 'large'.

Sea state conditions:

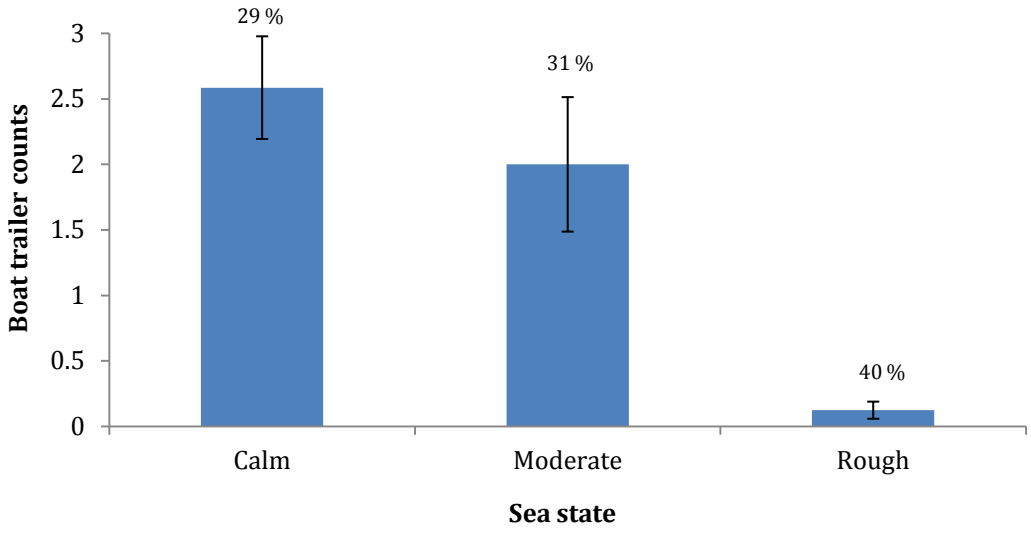


Figure 38. Boat trailer counts at Karitāne during different sea state conditions. Error bars denote standard error of the means. Numbers above error bars represent the percentage of total observations for each sea state condition. Actual observation numbers = 70 calm sea state observations; 75 moderate sea state observations; 99 rough sea state observations.

Weather conditions:

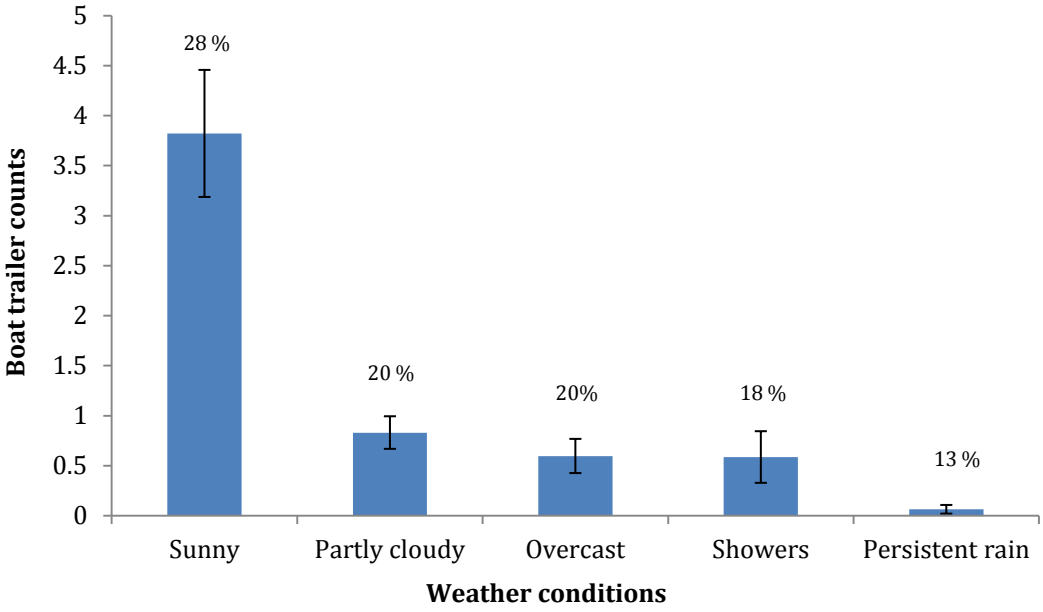


Figure 39. Boat trailer counts at Karitāne (specify exactly where) during different weather conditions. Error bars denote standard error of the means. Numbers above error bars represent percentage of total observations for each weather condition. Acutal observation numbers = 67 sunny observations; 48 partly cloudy observations; 48 overcast observations; 42 shower observations; 31 persistent rain observations.

Wind direction:

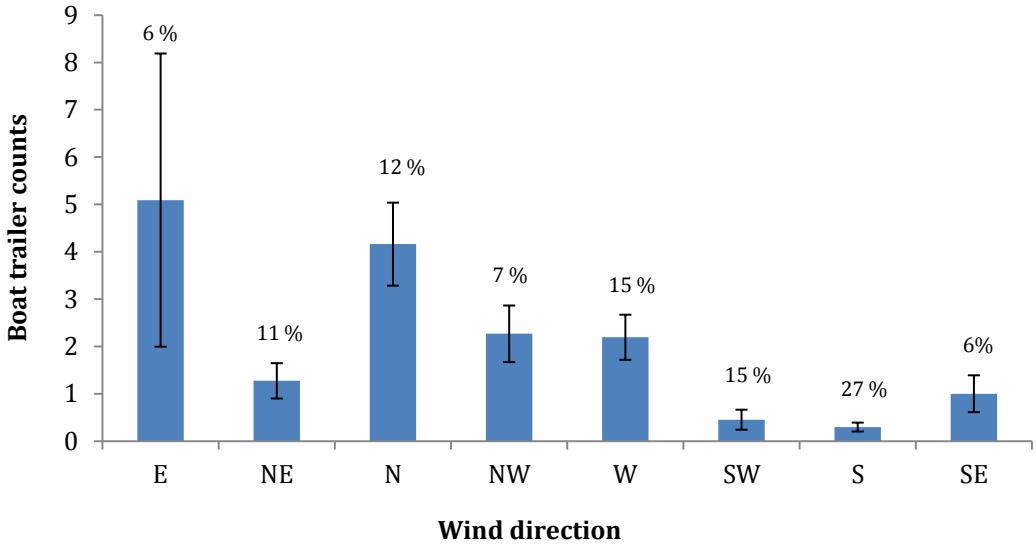


Figure 40. Boat trailer counts at Karitāne during different wind direction observations. Error bars denote standard error of means. Numbers above error bars represent percentage of total observations for each wind direction. Actual observation numbers = 11 E observations, 22 NE observations, 25 N observations, 15 NW observations, 31 W observations, 31 SW observations, 54 S observations; 12 SE observations.

Wind strength:

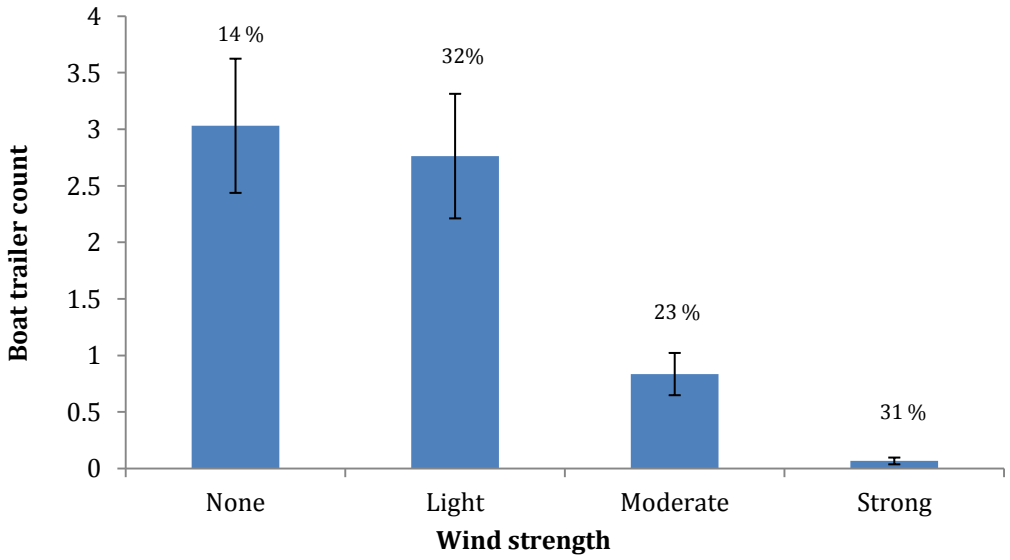
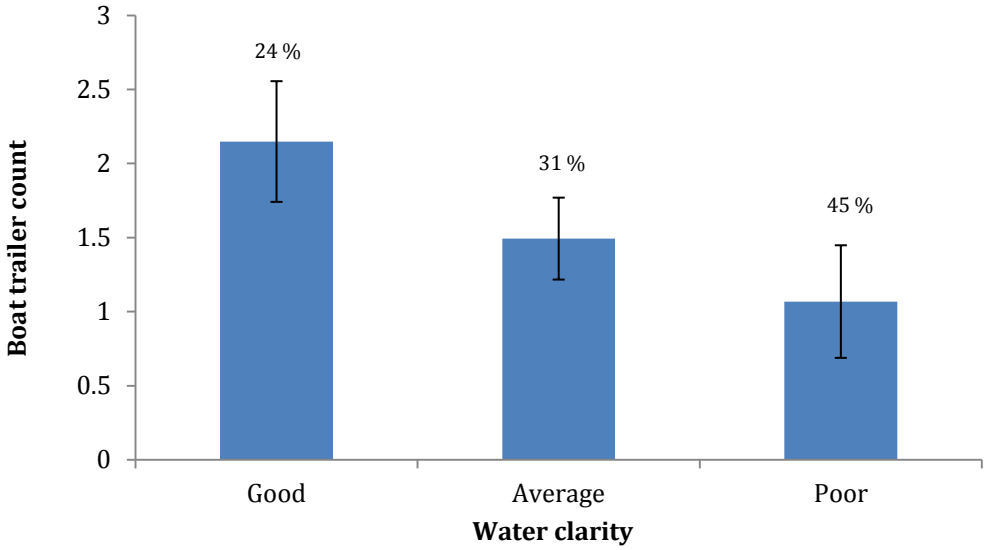


Figure 41. Boat trailer counts at Karitāne during different wind strength observations. Error bars denote standard error of means. Numbers above error bars represent the percentage of total observations for each category of wind strength. Actual observation numbers = 32 for 'none'; 76 for 'light'; 55 for 'moderate'; 73 for 'strong'.

Water clarity:



Figrue 42. Boat trailer counts at Karitāne during different water clarity observations. Error bars denote standard error of means. Numbers above error bars represent the percentage of total observations for each category of water clarity. Actual observation numbers = 54 observations of good water clarity; 71 observations of average water clarity; 103 observations of poor water clarity.

Time relative to high tide:

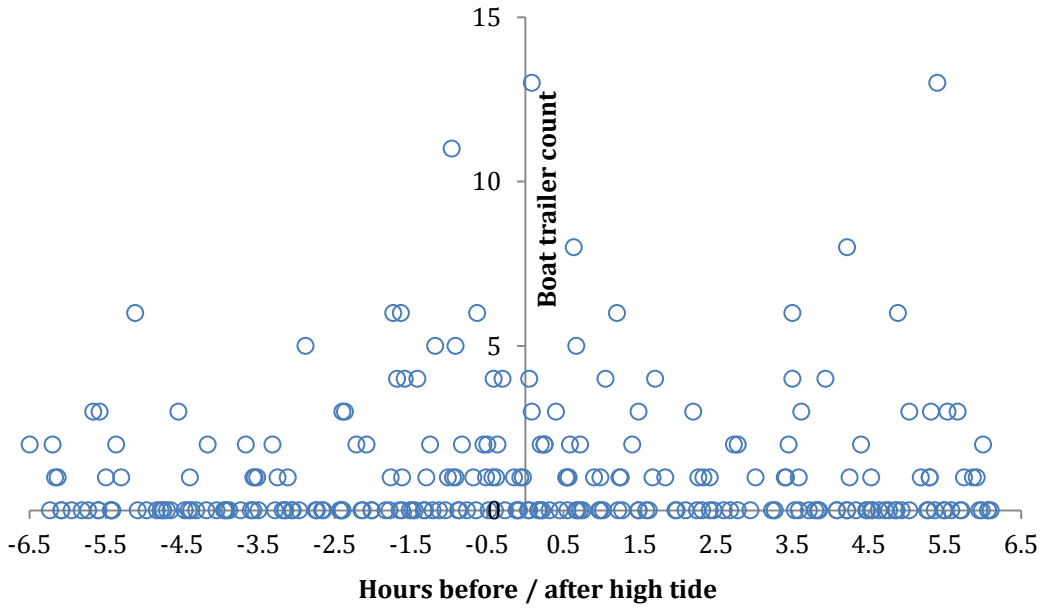


Figure 43. Boat trailer counts with respect to nearest high tide. N = 322 observations.

4 Discussion

4.1 Who is catching what?

The East Otago Taiāpure is an area which attracts much recreational fishing activity. The establishment of the *taiāpure* in 1999 is a testament to the areas' rich marine biodiversity, cultural and historical significance. While the majority of recreational fishers from this study resided locally (within a 25 km radius of the *taiāpure*), almost one fifth of those surveyed travelled over 200 km to fish within or just outside the *taiāpure*, further highlighting the area as a recreational fishing hot-spot.

Our intercept surveys suggest that a greater proportion of local Māori engage in recreation fishing on a regular basis when compared to the proportion of Māori actually living in the area, or the proportion of Māori residing in New Zealand as a whole (census 2006 data). This trend may imply that recreational fishing is of particular cultural and customary significance to Māori and more ingrained in their way of life. Indeed, recent studies investigating local perception of the state of near-shore fisheries stocks, revealed an inextricable link between the ability for Māori to regularly and easily gather *kai moana* (seafood) and the preservation of Māori culture, customs, tradition and heritage (McCarthy *et al*., 2013; Dick et al., 2013). In McCarthy et al. (2013), Māori participants of the study associated the depletion of certain inshore *kai* (food) species over recent decades with a loss of cultural identity and practices, and stress the importance of local management as well as the inclusion of traditional fisheries management methods (see also Hepburn et al., in prep). In these studies, *kaitiaki* and local people conveyed a deep concern with the current state of local fisheries and particularly the impacts of overfishing and mismanagement. Participants of the 2013 Marine Cultural Health Index (MCHI), a recent project enabling Ngāi Tahu communities to assess the health of local marine harvest areas, emphasize that many Māori prefer to recreationally and customarily fish within CPAs where stocks are perceivably healthier (Schweikert et al., 2013).

Gathering data on the patterns of recreational fishing activity within the East Otago Taiāpure is therefore essential for determining fishing impacts and ensuring that appropriate management methods are implemented.

The East Otago Taiāpure comprises a range of marine habitats suitable for large congregations of shellfish. Rocky intertidal reefs and lush kelp beds provide refuge for a range of frequently harvested shellfish including *pāua* (abalone), *kutai* (mussels), *tio* (oysters) and *kina* (sea urchin) as well a range of finfish species. Soft sediment flats within the *taiāpure* also provide one of the relatively few suitable environments in New Zealand for prolific *tuaki* (cockle) and *pīpī* growth. This was evidenced in the findings of this report, with over four fifths of those fishing within the *taiāpure* primarily targeting shellfish. The comparative ease of access to shellfish stocks at low tide and the lack of need for expensive equipment while harvesting may contribute to this general preference for shellfish gathering. In contrast, fishers venturing outside of the *taiāpure* targeted only finfish, suggesting that most shellfish habitats within the region are encompassed within the *taiāpure* itself. Concerns, however, over depletion of local shellfish stocks in a number of South Island locations, including the East Otago *taiāpure*, have been voiced (McCarthy et al., in press).

Approximately one third of all *pāua* gathered within the *taiāpure* were released back into the water; more so than any other shellfish species. *Pāua* are easily damaged when forcefully removed from rock surfaces with discarded *pāua* often unlikely to survive. The Ministry of Primary Industries (2007) describe the correct procedure when removing *pāua* to help prevent damage; "when collecting *pāua*, use *pāua* friendly tools (that is, no sharp instruments). Any damage to undersized *pāua* will significantly reduce their chances of survival. If unsuccessful in removing a *pāua* on the first attempt, leave it, because if it has clamped onto a rock it is extremely unlikely it will be prised loose without suffering damage". We suggest that fishers discarding individual *pāua* in order to comply with minimum size limits contribute to a greater proportion of *pāua* catch affected than just those caught and kept. Current measurements of harvest pressure on *pāua* populations may therefore be underestimated. Assuming that

no discarded *pāua* survive, our results suggest that the impact of recreational fishing on *pāua* stocks may be up to one third greater than previously estimated.

Recent studies identify *pāua* as both a *taonga* (treasured) species (Dick et al., 2013), and a cultural keystone species (McCarthy et al., in press), the gathering of which is described as an integral component of Māori culture, traditions and identity. It is therefore important to have an understanding of the full impact of recreational harvesting on *pāua* stocks and to take into account the proportion of *pāua* released and the methods of harvest. Measuring *pāua* prior to removal and bagging could significantly reduce the number of discarded *pāua* and therefore alleviate recreational fishing pressure on local *pāua* stocks.

The percentage of caught versus released finfish varied considerably for those fishing both within and outside the *taiāpure*. For some species, including blue cod, wrasse and parrot fish, a greater percentage of those caught were released rather than kept. Most fish released were undersized, while smaller proportions were released due to them being non-target species. Often wrasse and parrot fish were released to make room for blue cod catch. Likewise, with limits restricting the total catch of any combination of finfish species to 10 per person within the *taiāpure*, it is likely that some legal sized finfish were released in favour of larger individuals.

A high percentage of finfish were taken from areas outside the *taiāpure*. While catch per unit effort (CPUE) of finfish was slightly greater within the *taiāpure*, double the amount of fishing vessels ventured outside the *taiāpure* during the course of the survey. Increased fishing pressure just beyond the *taiāpure* boundary has implications for finfish metapopulations. A metapopulation consists of a group of spatially separated populations which interact at some level and may span vast areas (Kitzer and Sale, 2006). The connectivity of metapopulations mean that stress placed on one location, such as overfishing of near-shore stock, may trigger a chain reaction affecting different stocks and occasionally the metapopulation as a whole (Halpern et al., 2008; Watson et al., 2011). There is a risk that given the relatively small size of the East Otago Taiāpure compared with the large roaming range of some finfish species,

coupled with the increased fishing pressure beyond the *taiāpure* border, current fishing restrictions implemented within the *taiāpure* may have a negligible impact on fish sustainability, and may leave *kaitiakitanga* in reactive mode.

4.2 Are fishers complying?

All intercept survey data was collected during the year prior to the implementation of the 2010 East Otago Taiāpure regulation. In the interest of sustainable stock management, the regulation reduced the daily catch limit of certain shellfish and finfish species within the *taiāpure*, while also reducing the combined daily take of any finfish species from 30 to 10 per day (see Table 2). The regulation was also implemented alongside a two year *rāhui* (harvest ban), prohibiting the take of *pāua* from Huriawa peninsula from 01 October 2010 until 30 September 2012.

Pre regulation compliance:

The vast majority of recreational fishers in this study complied with pre-regulation restrictions. Only eight percent of cockle harvesters and five percent of mussel harvesters collected over the legal daily limit of 150 cockles and 50 mussels per person. While in the minority, there were three reported cases of individuals harvesting almost three times the legal daily take of cockles. Excellent compliance was reported for those harvesting *pāua*, oysters and *pīpī*, and particularly for those targeting finfish both within and outside the *taiāpure*. In fact, there was only one reported incident of a fisher exceeding the daily limit of 30 blue cod per person outside the *taiāpure*. The average daily take per person for the most frequently harvested finfish species (including blue cod, greenbone, flounder, moki, wrasse, jock stewart, trumpeter and parrot fish) fell well below the daily catch limits for these species, ranging from a low of 0.3 greenbone per person (outside the *taiāpure*) to a high of 5.6 blue cod per person (outside the *taiāpure*).

These relatively low daily catch rates of finfish both within and directly outside the *taiāpure* may be indicative of different scenarios. On one hand, the low catch rates may simply be a reflection of excellent compliance, with recreational

fishers harvesting only as much as they need. In this scenario, the legal catch limits for the eight species listed above well exceed the needs of recreational fishers. Alternatively, the catch rates may indicate that local finfish stocks have been fished down to a level that does not allow recreational fishers to catch near the compliance limit. Should this be the case, the current limits would do little to sustain local finfish stocks and our population estimates of finfish stocks would require serious revision.

Population estimates and quotas for individual stocks are heavily based on trends in CPUE from large monitoring areas within which quotas are allocated, but may also include the use of research surveys, ships' logs, landed catches and computer modeling (Walrond, 2012). However, reliable inference from CPUE data may be problematic as raw CPUE is seldom proportional to abundance and does not account for numerous factors that affect catch rates (Prince and Hilborn, 1998; Rose and Kulka, 1999; Dunn et al., 2000; Harley et al., 2001; Moller et al., 2004; Maunder et al., 2006). Furthermore, aggregating commercial catch data over comparatively large areas excludes added fishing pressure from recreational and customary fishers and overlooks finer scale variation in fish and invertebrate populations (Hepburn et al., in prep). Analysing commercial, recreational and customary catch data over scales relevant to the East Otago Taiāpure is essential for determining appropriate daily catch limits within the *taiāpure* boundary. This report provides an initial look at the scope and magnitude of recreational fishing activity within and around the *taiāpure*.

Post regulation compliance:

By comparing our recreational fishing data with changes implemented by the 2010 regulation, we discover a significant increase in the percentage of fishers exceeding the daily bag limit for both cockles and *pāua*. The regulation reduced the daily cockle take from 150 to 50 per person, and halved the pāua take from 10 to five per person. Assuming that reported recreational fishing rates remain unchanged, our data suggest that almost 12% of *pāua* gatherers and 60% of cockle gatherers are exceeding the regulation catch limit. Certainly there is a compliance issue for cockle gatherers, with the majority of people harvesting

between 51 and 150 cockles per person. However, stable and plentiful cockle populations may offset the ecological impacts of non compliance from recreational fishers.

The new *pāua* gathering regulations and the *rāhui* at Huriawa peninsula were implemented by the East Otago Taiāpure committee following observations of severely declining *pāua* populations. A non compliance rate of 12%, while low, may further deplete local populations, especially when incorporating the added fishing pressure of discarded and damaged catch, potentially accounting for up to a third of all *pāua* caught. Furthermore, the slow growth rate, low recruitment, limited dispersal range and aggregated nature of *pāua* (Sainsbury, 1982; Prince et al., 1987; McShane and Naylor, 1995a; McShane and Naylor, 1995b; McShane and Naylor, 1996) means that locally depleted *pāua* populations are unlikely to be replenished by nearby stocks.

Approximately one third of all *pāua* gatherers within the *taiāpure* collected from Huriawa Peninsula and the wider Puketeraki area. The two year *rāhui* at Huriawa Peninsula looked to replenish depleted populations, but may have shifted fishing pressure to other popular *pāua* gathering sites such as the north end of Warrington Beach. A follow up study is required to accurately gauge the level compliance of recreational fishers following regulation changes.

Is the fishery protected by bag limits?

Theoretically reducing daily catch limits allows us to test which catch limits become effective in altering fishing behavior. With the exception of blue cod, none of the other predominantly caught finfish were affected by the recently established daily catch limit of 10 fish per person[3]. In fact, compliance issues are only detected for jock stewart, parrot fish, wrasse, greenbone and moki when the theoretical daily catch limit is reduced to three fish per person. In other words, should there be a genuine concern for the sustainability of these fish, daily catch limits would need to be reduced to three per person before noticeable changes were observed.

[3] Referring to the 2010 East Otago Taiāpure fishing regulations (see Table 2).

It should be noted that none of those catching finfish within the *taiāpure* reported fishing north of Huriawa (i.e. not Waikouaiti Bay). As the 2010 regulations reduced daily limits for finfish within the *taiāpure* only for the area south of Huriawa, we can be confident that our estimates of theoretical catch compliance are more likely to reflect actual take.

Provided that fishers abide regulations, the recent reductions in daily shellfish take, as implemented by the 2010 regulation, is likely to affect cockle and *pāua* harvests. However, daily catch limits for oysters, *pīpī* and mussels would need to be reduced from 50 to 40 per person before recreational fishers are affected. An investigation to determine whether the low reported finfish catches are a product of good compliance or an exhausted resource is needed to determine the sustainability of the current set limits.

4.3 Is the fishery protected by weather?

Observation surveys conducted at Karitāne revealed a strong relationship between weather conditions and recreational fishing activity within the *taiāpure*. Boat trailer counts and weather observations were recorded on randomly selected days, up to six days a week, over the course of a year. The data suggest that a suite of poor conditions reduce recreational fishing activity. Wind direction was a dominant factor, with prevailing cool south-westerly and southerly winds yielding lowest recreational fishing activity. Strong winds, rough seas, rain, poor water clarity and large sea swells also contributed to unfavourable fishing conditions, and were typically all associated with southerly, south-westerly or south-easterly winds. Likewise, fishing activity was also found to be lowest in winter, during which conditions are classically harshest. An overall assessment of these factors reveals that recreational fishing activity is deterred for approximately half the year by a combination of poor conditions.

By way of explanation, poor conditions effectively protect local fisheries by reducing recreational fishing pressure and allowing for greater recovery times of near shore stock. Boat trailer counts were used as the proxy for recreational

fishing activity, therefore these findings are limited only to fisheries harvested directly by boat. The use of rods and lines from boats was the second most common fishing method after hand gathering from shore, accounting for approximately one third of all those surveyed. Other boating activity including trawling, drag netting and cray-potting accounted for a further five percent. By and large these finding suggest that weather provides periodic protection for free-swimming and pelagic species and affect the behaviour of at least one third of recreational fishers in the area.

The East Otago Taiāpure is predominantly an exposed stretch of coastline, open to prevailing winds, periodic storms and unabated swell. Exposed coastlines provide a larger buffer against recreational fishing activity from boats than sheltered coastlines such as the Waitemata Harbour and parts of the Hauraki Gulf. Aerial surveys conducted over the Waitemata Harbour and Hauraki Gulf revealed highest concentrations of recreational fishing activity typically within sheltered areas, along channels and within close proximity to aquaculture farms (NABIS, 2013). These factors, coupled with Auckland's large population contribute to high recreational fishing pressure within the area. The comparatively low populations of most South Island settlements, including the East Otago Taiāpure, also act as buffers against recreational overfishing. However, lower risks due to lower populations and frequent unfavourable fishing conditions are not evidence that the fishery is sustainable. In fact the *taiāpure*'s close proximity to Dunedin City and its reputation as a sought-after fishing ground may negate some of these buffers in the near future.

4.4 Shortcomings and recommendations

1. *Focus species*

Based on the findings of this report, we recommend that management emphasis be given to blue cod, cockles and *pāua*. These three species proved to be popular target species among recreational fishers, and were the only species where catch compliance issues were observed. Increased signage of fishing regulations at

appropriate locations may be enough to deter most from over-harvesting shellfish.

2. *Information gaps*

- The intercept surveys were designed to intercept recreational fishers landing within the East Otago Taiāpure. However, a potentially significant number of fishing vessels from Port Chalmers, Dunedin periodically fish within and directly outside the *taiāpure* and remain unaccounted for. Follow up surveys conducted at Port Chalmers would shed light on added fishing pressure from Dunedin vessels.

- A lack of perception survey responses did not allow for analysis of what local fishers value, their level of understanding of the vision of the East Otago Taiāpure and its regulations, or how locals would like their marine resources managed. A minimum of 40 perception surveys is required for the sake of sound statistical analysis.

- An investigation to determine whether the low reported finfish catches are a product of good compliance or an exhausted resource is needed to determine the sustainability of the current catch limits.

- Different monitoring methods may be adopted to assess the sustainability of current catch limit regulations and recreational fishing activity on local fisheries within and around the *taiāpure*. Demographic monitoring would allow for forecast estimates of population trends. To achieve this, regular boat trailer counts (to estimate average fishing activity of finfish gatherers) and shoreline scan counts (to estimate average fishing activity of shellfish gatherers) would be fitted against intercept survey data (detailing average catch of each species) to estimate total removal of species within the *taiāpure* over a given timeframe. Eventually this can be scaled against productivity of the *taiāpure* fisheries for formal sustainability assessments. However, this requires accurate baseline estimates of finfish and shellfish populations, usually attained through scientific surveys of fish stocks.

In the absence of baseline estimates and sustainability assessments, *kaitiaki* may look to adopt trend analysis using repeatable measures (i.e. repeating surveys over a long term timeframe and looking for signs of change in recreational fishing activity). This study showed that reliable data could be obtained relatively cheaply. Repeating the surveys every three to five years would alert *kaitiaki* to whether fishing success (and therefore stocks) is being altered by regulations.

3. *Empowering kaitiaki*

Employ adaptive co-management by incorporating the marine cultural health index (MCHI) and rapid scientific inventory methods alongside recreational survey data in order to provide *kaitiaki* and the East Otago Taiāpure committee with a suite of useful management tools. Such tools would provide information regarding recreational fishing activity, nearshore ecosystem and fisheries health, and species population and biodiversity data.

Establish a coordinated longer-term monitoring program inside and outside CPAs with reference areas. The East Otago Taiāpure may act as one of several treatments alongside marine reserves serving as control sites.

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Appendix A: Glossary

Key Kupu	Definition
Hapū	Sub-tribe; kinship group
Kai	Food
Kaitiaki	Custodian; guardian; minder; keeper
Kaitiakitanga	Guardianship
Kawa	Protocols
Kutai	Mussels;
Mahinga Kai	The practice of customary food gathering; places where food is collected and the resources themselves
Mana	Prestige; authority; spiritual power; control; status
Māori	Native/indigenous people of New Zealand
Marae	Traditional Māori meeting place
Mātaitai	An identified traditional fishing ground which has special status under the Fisheries Act 1996 to protect customary fishing values. Commercial fishing is usually excluded from mātaitai reserves.
Mātauranga	Māori knowledge
Moana	Sea; ocean; large lake
Pāua	Abalone; *Haliotis iris*
Pipi	Endemic bivalve/clam
Rāhui	Harvest ban
Rāwaru	Blue cod
Taiāpure	Local management tool established in an area that has customarily been of special significance to an iwi or hapū as a source of food or for spiritual or cultural reasons. Commercial fishing occurs in taiāpure reserves but may be subject to taiāpure rules.
Tangata Tiaki	Individuals who can authorise customary fishing within their rohe moana, in accordance with tikanga Māori.
Tangata Whenua	Peaople of the land
Taonga	Treasure; property; possessions
Tikanga	Customs; Lore
Tio	Oyster