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EXECUTIVE SUMMARY

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An interview survey of access points was undertaken to estimate the recreational catch of scallops and dredge oysters in the Golden Bay and Tasman Bay sections of the Southern Scallop fishery (SCA7). The objectives of the survey were to: (i) estimate the recreational catch of scallops for the 2003–04 fishing season (15 July 2003 to 14 February 2004), and (ii) estimate the recreational catch of dredge oysters taken over the same period. Sampling was stratified by access point (14 boat ramps, 1 marina), season (winter, summer), and day type (weekday, weekend/statutory holiday).

The estimated total catch of scallops from the surveyed area was 860 000 scallops (95% confidence interval 780 000–940 000). This equates to 9.4 t of meat weight. Scallop catches were clumped at the bag limit of 50 per fisher, with a few exceedances. Sub-limit bags were most prevalent in Golden Bay, where catches were low. Most fishers caught scallops by dredging, though diving accounted for 19% of the catch landed from Croisilles Harbour. Nearly all interviewees fished from trailer boats. Winter catches were generally higher than summer catches, but sea condition and windspeed explained little variance in total catch. The proportion of undersized catch was highest in Golden Bay and lowest at Croisilles Harbour.

Oyster catch was very small, averaging about 1 per vessel per scalloping trip, and was greatest in Tasman Bay. An estimated 5800 oysters (95% confidence interval 3800–8400) were taken recreationally during the season.

1. INTRODUCTION

This document reports the results of Ministry of Fisheries Project REC2002/03, Objectives 1 and 2. The project objectives are as follows.

1. To estimate the recreational catch of scallops in the Golden Bay and Tasman Bay sections of the Southern Scallop fishery (SCA 7) for the 2003–04 fishing season (15 July 2003 to 14 February 2004).
2. To estimate the recreational catch of dredge oysters taken over the same period.

The Southern Scallop (SCA 7) fishery is highly valued by commercial, recreational, and customary fishers. Fine-scale catch information is routinely collected on the commercial fishery. Detailed information from kaitiaki should soon become available to quantify the customary catch. The work presented here is intended to provide reliable estimates of recreational catch.

1.1 The commercial fishery

The Southern Scallop fishery comprises Tasman Bay, Golden Bay, and the Marlborough Sounds, and is divided into 12 sectors (A–L, Figure 1). Up to 1980, the commercial fishery was managed with a combination of gear restrictions, closed areas and seasons, and a 100 mm minimum legal size (MLS), together with limitations on the number of entrants (from 1977). About 200 vessels were involved in the fishery in 1975. Landings peaked in 1975, then declined, leading to the closure of the fishery in 1981 and 1982. Only 48 licences were issued when it re-opened in 1983, with each vessel being allocated a defined, and equal, catch limit on an annual basis. A scallop enhancement programme was initiated in the same year. By 1989 the success of the enhancement programme enabled rotational fishing in Tasman and Golden Bays (Sectors A–I). Initially, several sectors were opened to commercial fishing each year, and were re-seeded following fishing down. Rotational fishing was accompanied by a reduction in the MLS to 90 mm.

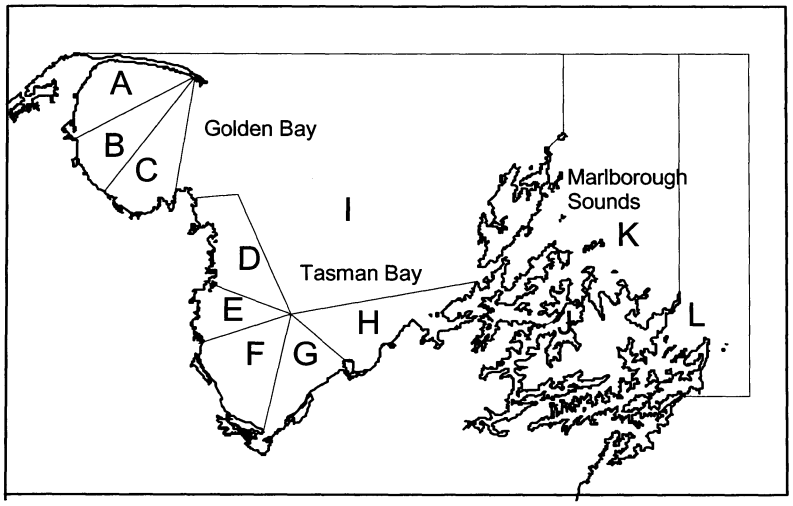

Figure 1: Golden Bay, Tasman Bay, and the Marlborough Sounds, showing the sectors defined for scallop enhancement purposes.

The Challenger scallop fishery was introduced into a modified form of the Quota Management system (QMS) in 1992: 640 t (12 t to each of the 48 licence holders, plus 64 t to Maori) was initially allocated as ITQ. Provision was made for any available quota in excess of the 640 t to be allocated to the Crown for lease, with preference being given to existing quota holders. From October 1995, legislation changed the fishery into a proportional quota management system, and a statutory Enhancement Plan

to support the fishery was approved (the enhancement programme aims to reduce the severity of any troughs in natural recruitment).

Management of the fishery now includes rotational fishing (i.e., commercial fishing is allowed only in specific sectors each year), and enhancement of the natural stock (i.e., distribution of juvenile scallops in areas that are to be fished or have low scallop densities). An annual dredge survey helps define biomass levels and population size structure, by sector (Challenger Scallop Enhancement Company, unpubl. results). This approach enables the fishery to concentrate in areas where scallops are predominantly above the minimum legal size, and reduces disturbance in areas where most of the population is sub-legal.

The commercial season runs from 15 July to 14 February, although fishing usually occurs only from August to December. Opening and closing dates are defined each year by the Challenger Scallop Enhancement Company, and may differ between years. Landings from the commercial fishery have ranged between 205 and 850 t meatweight since the 1983–84 season.

1.2 The recreational fishery

Estimates of recreational catch have been obtained on three occasions. In 1992–93 the recreational catch was estimated from a telephone and diary survey to be 22 t meatweight (Teirney et al. 1997). A national diary survey in 1996 gave an estimate of 19 t (Bradford 1998). These two estimates are considered to be very uncertain and probably under-estimate the recreational catch. A nationwide telephone and diary survey in 1999–2000 suggested a recreational harvest of about 44 t meatweight. However, anecdotal information has suggested that the actual recreational catch could be much higher — perhaps in the order of 100 t meatweight. The Marine Recreational Fisheries Technical Subgroup has identified issues with telephone-diary surveys, and recommended "*that the telephone-diary estimates* [of recreational harvest] *be used only with the following qualifications: 1, they may be very inaccurate; 2. the 1996 and earlier surveys contain a methodological error; and 3, the 2000 and 2001 estimates are implausibly high for many important fisheries.*"

To effectively manage extractions from the fishery, a greater level of certainty over the extent of the recreational catch is required. The national programme established for estimating recreational harvest does not quantify the recreational take on the fine scale required for the SCA 7 fishery. We report here the results of an access point survey to provide estimates of the recreational scallop and dredge oyster catch in Tasman Bay (including Croisilles Harbour) and Golden Bay.

2. SURVEY DESIGN

The sectors surveyed under this project were A, B, C, D, E, F, G, H, and I (Figure 1). The Marlborough Sounds sectors (J, K, and L) were not included.

The recreational scallop catch from Tasman and Golden Bays is taken almost exclusively by dredging or scuba diving from small trailer boats. There is a small (and probably negligible) component taken by shore-based diving, which would be very difficult to survey. Another component is taken by larger marina-based vessels, either on private trips, or chartered by groups of recreational fishers. Because there are relatively few boat ramps, and only one marina, in the survey area, surveys at these access points will cover virtually all the recreational catch. Hence, an access point survey with a spatiotemporal sampling frame (Pollock et al. 1994) was designed. This method involves interviewing fishers at the completion of their trip, with interview sites chosen randomly, with known probability, from a list of all access points and from all days of the fishing season.

2.1 Stratification

Sampling was stratified by access point (14 boat ramps and one marina), by season (winter, summer), and by day type (weekday, weekend/statutory holiday). Winter was defined as 15 July to 30 November, and summer as 1 December to 14 February. Hence, there are 60 sampling strata.

When nothing is known about the temporal patterns of effort in a fishery, samples should be chosen with equal probability from all the days available. However, more frequent sampling when fishing is heavy will result in more precise estimates of catch (Pollock et al. 1994). Some information is available on the distribution of recreational fishing traffic, by season and day type, at the Okiwi Bay and Port Nelson boat ramps from a survey conducted in 1996 (Hartill et al. 1998). The data (Table 1) indicate that there is little difference between summer and winter in the frequency of weekend fishing trips, but the frequency of weekday trips was much lower than that of weekend trips. However, the boat ramps surveyed by Hartill et al. (1998) would rank as two of the most heavily patronised in the area, and they may not be representative of those to be surveyed. A priori we would expect the frequency of use of some of the other ramps, particularly those adjacent to camping grounds (e.g., Kaiteriteri, Totaranui, Tukurua), to be greater in summer than in winter.

Table 1: Mean number of recreational fishing boats per hour (Mean) encountered per interview session at the Port Nelson and Okiwi Bay boat ramps, by season and day type in 1996. Each interview session was 4 h long. *N*, number of sessions; –, no data.

Season	Day type	Port Nelson		Okiwi Bay	
		Mean	*N*	Mean	*N*
Winter	Weekday	–	0	–	0
	Weekend	7.5	6	4.3	6
Summer	Weekday	2.0	10	0.0	2
	Weekend	6.3	8	3.3	11

The chosen stratification by time (i.e., season, and day type) does not result in equal numbers of days per stratum because the season defined as winter is longer than the summer sampling period, and there are about 2.5 times as many week-days are there are weekend days. Days by stratum for the period 15 July 2003 to 14 February 2004 are shown in Table 2.

There is no numerical information from which to determine the number of sampling days necessary in each time stratum at each ramp. The boat ramp survey in 1996 encountered recreational fishing vessels at a rate of about 7 per hour (i.e., 25–30 in a 4-hour interview session) at the Port Nelson site on weekends/holidays, which is likely to be the most frequently patronised of all the ramps. At some of the less-used ramps, in some time strata, the encounter rate is likely to be zero. Some of the recreational vessels using the ramps will not have fished for scallops, but there is no information on the likely proportion.

Table 2: Available days by stratum under the proposed time stratification regime. "Holiday" includes all statutory holidays.

Season	Day type	Available days
Winter	Weekday	98
	Weekend/Holiday	41
Summer	Weekday	50
	Weekend/Holiday	26

Based on perceived patterns of recreational fishing intensity, a sampling programme as set out in Table 3 was devised, comprising 300 sampling days. This sampling regime aimed to ensure more frequent sampling when fishing is more frequent, resulting in more precise estimates of catch (Pollock et al. 1994). Sampling dates were randomly predetermined before any sampling began.

Table 3: Proposed number of sampling days by stratum. "Holiday" includes all statutory holidays.

Access point	Winter		Summer	
	Weekday	Weekend & holiday	Weekday	Weekend & holiday
Okiwi Bay	6	6	8	9
Port Nelson	8	8	10	12
Nelson Marina	0	4	6	8
Monaco	0	4	4	6
Rabbit Island	0	4	4	6
Mapua	0	4	4	6
Motueka	4	6	6	8
Kaiteriteri	6	6	8	8
Marahau	4	4	5	6
Totaranui	0	0	4	4
Tata Beach	4	4	4	4
Tarakohe	6	8	8	8
Pohara	0	4	5	6
Tukurua	0	0	4	4
Collingwood	5	6	6	8

2.2 Session times

Each day of sampling (i.e., a sampling session) was of 7 hours duration, with sampling conducted between 0800 and 1900 NZST. All ramps were classified as being either tidally independent (i.e., able to be used at any time in the tidal cycle) or tidally dependent (i.e., unable to be used for some time either side of low tide). At tidally independent ramps, recreational landings of scallops were considered likely to be more prevalent in the afternoon than in the morning, as it was assumed vessels would generally depart in the morning and return later in the day. Consequently, the sampling session was split into two parts. Two hours of continuous sampling, beginning at a randomly determined time, occurred between 0800 and 1200 NZST. An additional period of five hours of continuous sampling, again with a randomly determined start time, occurred between 1200 and 1900 NZST. At tidally dependent ramps, sampling was confined to times when the ramp is functional. This resulted in a single sampling period of 7 hours bracketing the high tide.

2.3 Survey data

For all boats arriving at an access point during a sampling session, the following information was recorded. (A record form is shown in Appendix A.)

- Did those on board fish for scallops
- How many persons on board fished for scallops
- How many scallops do they have on board
- What was the approximate locality of the scallop fishing (i.e., which sector)
- What fishing method was used
- What was the time at landing

A request was then made to measure the shell lengths of 20 randomly chosen scallops from the catch.

Some fishers refused to take part in a boat ramp survey. When refusals were encountered, their incidence was noted and these parties were included in any estimation of the number of fishing parties returning to that ramp. Soft refusals, when fishers appear willing but withhold information to reduce the length of the interview, are more problematic (i.e., fishers who give "no catch" or "not fishing for scallops" type answers when scuba gear or scallop dredges are visible on the boat). When interviewers suspected a soft refusal that could not be confirmed, or suspected the withholding of information, they recorded this suspicion and the reason for it. If possible, the interviewer estimated the number of scallops on board (e.g., from a wet sack obviously containing catch). Catch rates and harvests by parties refusing interviews outright or otherwise were treated as typical of those parties who consented to be interviewed.

The recreational catch of dredge oysters from Tasman and Golden Bays is taken mainly as a bycatch of fishing for scallops, although there is limited recreational targeting for this resource also. Clearly, therefore, any estimation of the catch of dredge oysters is best done in tandem with the proposed scallop survey. This simply involved two additional questions being asked at the time of the session interviews.

- Did those on board fish for oysters?
- How many oysters do they have on board?

If oysters had been taken, a request was then made to measure the shell lengths and widths of 10 randomly chosen oysters.

The survey aimed to estimate both the number and meatweight of scallops caught recreationally. Deriving meatweight from greenweight would be imprecise owing to a reduction in the amount of water retained by scallops as time since capture increases, and the relatively small proportion of meatweight relative to greenweight. Consequently, the recreational landings were not weighed. Instead, counts of scallops in the recreational catch and their estimated size distribution were used to infer the meatweight of landings. Previous survey estimates have assumed all scallops had a meatweight of 13 g (Annala et al. 2002). Meatweight (i.e., muscle plus gonad) can vary seasonally, often reaching a peak about September–November with a decline from December (P. Horn, NIWA, unpublished data). Similar meatweight trends have been demonstrated in the northern scallop fishery (Cryer & Parkinson 2004). Meatweight will also vary with shell size, i.e., a larger scallop shell will contain, on average, a heavier meatweight. It has also been found that there can be areal differences in meatweights, i.e., scallops of the same size, harvested at the same time, but from different areas can have markedly different meatweights. Clearly, assuming a constant meatweight per scallop could lead to inaccuracy in the estimate of total harvest weight, but accurately estimating the actual weight of the harvest over time and area would also be problematical.

Data on mean meatweights by sector by week from the commercial harvest were available from late September to late November in Golden Bay, and from late September to early February in Tasman Bay (Challenger Scallop Enhancement Company, unpubl. results). These data indicated that scallop meatweight in Golden Bay remained relatively constant at about 12 g during the period of commercial harvest. In the commercially harvested sectors in Tasman Bay, mean scallop meatweight also remained quite constant throughout the season at about 10.5 g. There was no indication of a post-Christmas decline in meatweights. No commercial meatweight data were available for Croisilles Harbour. No scallop shell length data were available from the commercial harvest, so it was not possible to develop a length-weight regression to convert estimated length frequency distributions to estimated meatweight. However, because meatweight appeared to remain relatively constant throughout the season, and because there was a large degree of overlap in the areas fished by recreational and commercial fishers, particularly in Tasman Bay, it was considered appropriate to use constant scallop weights throughout the season to estimate the recreational meatweight catch. (The MLS is the same for recreational and commercial fishers.) The meatweights used were 12 g for Golden Bay scallops, and 10.5 g for Tasman Bay scallops.

No meatweight data were available for Croisilles Harbour scallops. However, it was apparent that the mean shell length of the recreational catch of Croisilles scallops was about 2.0 mm greater than the

Tasman Bay catch in winter, and 3.7 mm greater in summer. Based on a selection of length-weight regressions derived from previous dredge surveys in Tasman Bay (Challenger Scallop Enhancement Company, unpubl. results), this greater length is likely to equate to a meatweight greater by about 1 g. Hence, a meatweight of 11.5 g was used for Croisilles Harbour scallops.

Weather variables for Tasman Bay were recorded for all days during the sampling period (Appendix A). These data were considered likely to be useful for post-stratification as described below.

2.4 Adaptive sampling

The proposed sampling regime was based on virtually no prior knowledge. We knew little other than that effort was likely to be more concentrated at weekends and holidays, so we used perceived fishing patterns to allocate numbers of sampling days to particular access points. However, we believe it was possible that information derived early in the survey could justify some changes to the allocation of sampling effort later in the survey.

The proposed sampling regime was generally adhered to (Table 4). However, the Rabbit Island ramp became unusable due to erosion during the winter season, and we received information that during the summer season this ramp was used almost exclusively by waterskiers. Consequently, three winter samples at this site were not completed, and the four proposed weekday summer samples were reallocated (at the start of the summer season) to the Port Nelson and Motueka ramps where scallop landings were expected to be frequent. Three of the winter sampling days at Marahau were dropped as it became apparent that negligible scallop landings were made at this location.

Adaptive sampling can introduce a bias if there are temporal trends in the recreational harvest across the survey. For example, by removing a sample from a stratum before that stratum has been completed, you are decreasing the probability that a day later in the stratum will be sampled. However, the chance of any bias from the adaptive sampling conducted here is believed to be negligible. Sampling dates were randomly added to summer strata (Port Nelson and Motueka) before sampling in those strata had commenced, and were deleted from the Rabbit Island ramp before sampling had commenced (summer) or because the ramp became inoperative (winter). Only in the Marahau winter stratum is bias possible (sampling stopped part-way through the winter season), but only one landing of scallops was recorded from that ramp in the five days of winter sampling.

Table 4: Number of completed samples by stratum. "Holiday" includes all statutory holidays.

Access point	Winter		Summer	
	Weekday	Weekend & holiday	Weekday	Weekend & holiday
Okiwi Bay	6	6	8	9
Port Nelson	8	8	12	13
Nelson Marina	0	4	6	8
Monaco	0	4	4	6
Rabbit Island	0	1	0	5
Mapua	0	4	4	6
Motueka	4	6	7	8
Kaiteriteri	6	6	8	8
Marahau	3	2	5	6
Totaranui	0	0	4	4
Tata Beach	4	4	4	4
Tarakohe	6	8	8	8
Pohara	0	4	5	6
Tukurua	0	0	4	4
Collingwood	5	6	6	8

3. DATA ANALYSIS

Each returning trip (where scallops were landed) produced an estimate of catch per fisher and catch (number of scallops) for the whole trip. The unit of catch analysed was the number of scallops landed and the unit of catch per unit effort analysed was the number of scallops landed per vessel per trip. This was simpler to analyse than catch per fisher, and inspection of tabulations of catch per fisher by classification variables (Appendix B) did not reveal any systematic bias. (For example, if vessels with one or two fishers typically landed more scallops per fisher than vessels with more than six, a biased analysis might emerge.)

The data sampling was stratified by boat ramp. However, estimation of recreational catch could be stratified by boat ramp or by area of catch (i.e., sector, Figure 1). We tabulate catch by both variables, but the main analysis is done by boat ramp.

The total number of scallops caught (H) was estimated as follows:

Total Harvest (H) =

$$\sum_i \frac{D_i}{d_i} \sum_1^N \left[\frac{\sum_j C(am)_j}{0.40} + \frac{\sum_j C(pm)_j}{0.83} \right] + \sum \frac{D_k}{d_k} \sum_1^T \left[\sum C(am)_j + \sum C(pm)_j \right]$$

Non-tidal ramps Tidal ramps

where D_i/d_i and D_k/d_k scale the sampled days (d) up to the total number of days (D) in the stratum, N is the number of non-tidal ramps, T is the number of tidal ramps, 0.40 and 0.83 are the morning and afternoon scalars to account for the incomplete sampling of all hours between 0800 and 1900 at tidally independent ramps, and ΣC_{am} and ΣC_{pm} are the sums of all scallops observed landed in all the j morning and afternoon sessions, respectively. For each tidally dependent ramp, the sample period of 7 hours is assumed to have included all the time that the ramp is functional, so scalars are not required. Total recreational harvest is the sum, over all ramps, seasons, and day types, of each estimated C.

The time of day of each landing was recorded. If the rate of landings had varied strongly with time of day, post-stratification of the landings might have been useful. However, this was not the case. It was also possible that a relationship existed between the observed landings rate and the weather variables. However, again, this was not the case. We present graphical evidence to support these statements in the Results.

Estimation of the variance of recreational harvest estimates is problematic as recreational catch rates do not generally conform to commonly used statistical distributions (Bradford 2000). Recreational finfish trips often catch none of the target species, resulting in a distribution skewed towards zero. However, a zero catch when scallops are targeted will probably occur rarely. It is believed that recreational catches of scallops could well be skewed towards the catch limit (i.e., 50 scallops per person). The best parametric approach to estimating average harvest rates and their variance was therefore difficult to specify without having first collected the data. The development of appropriate statistical descriptors of recreational catch rates is an ongoing area of research. To avoid any assumptions about statistical distributions, we therefore adopted a non-parametric bootstrapping approach to variance estimation by re-sampling catch and effort data with replacement (as in Bradford 2000). The standard deviation of the 100 000 bootstrap estimates was taken as an estimate of the standard error of the harvest, and confidence intervals can be defined using percentiles from the distribution of bootstraps (allowing for skewed harvest rate distributions).

Bootstrapping was done with 100 000 replications of a percentile bootstrap macro written in SAS. A minimum sample size of 30 is recommended for bootstrap resampling (Efron & Tibshirani 1993);

however, the number of vessels interviewed per ramp per season and per sector per season was generally well below that number, necessitating pooling of ramps. As Croisilles Harbour demonstrated different characteristics from the remainder of the fishery, it was used as one stratum, with Tasman Bay and Golden Bay the other strata.

The number of oysters taken by the recreational fishery (and sample variance) was estimated in the same way as described for scallops above.

Length-frequency distributions for scallops were calculated for each bay (Golden Bay, Tasman Bay, Croisilles Harbour) and season as follows. Length data from each ramp were scaled by the number of landings of scallops and the mean catch per landing at that ramp. The ramp distributions were then summed by bay, with the sum scaled to the estimated harvest from that bay.

The length-frequency distribution for oysters was simply a distribution of the 'size' of all measured oysters (i.e., there was no scaling, or separation by bay or season). Because oysters are irregular in shape, oyster 'size' was calculated as the mean of shell length and shell width. This is the method used to determine the frequency distribution of oysters taken during the annual survey of scallops and oysters (Challenger Scallop Enhancement Company, unpubl. results).

4. RESULTS

All data collected during the survey have been loaded onto the *rec_data* database administered by NIWA for the Ministry of Fisheries.

4.1 Scallop catch

The frequency distribution of catches per fisher was clearly clumped at the bag limit of 50, with a moderately dense distribution of sub-limit catches, and scattered catches that exceeded the limit (Figure 2A). Winter catches included fewer zeroes and fewer great exceedances of the bag limit (Figure 2B) whereas summer catches had a greater proportion of zeroes, and some very high catches (Figure 2C).

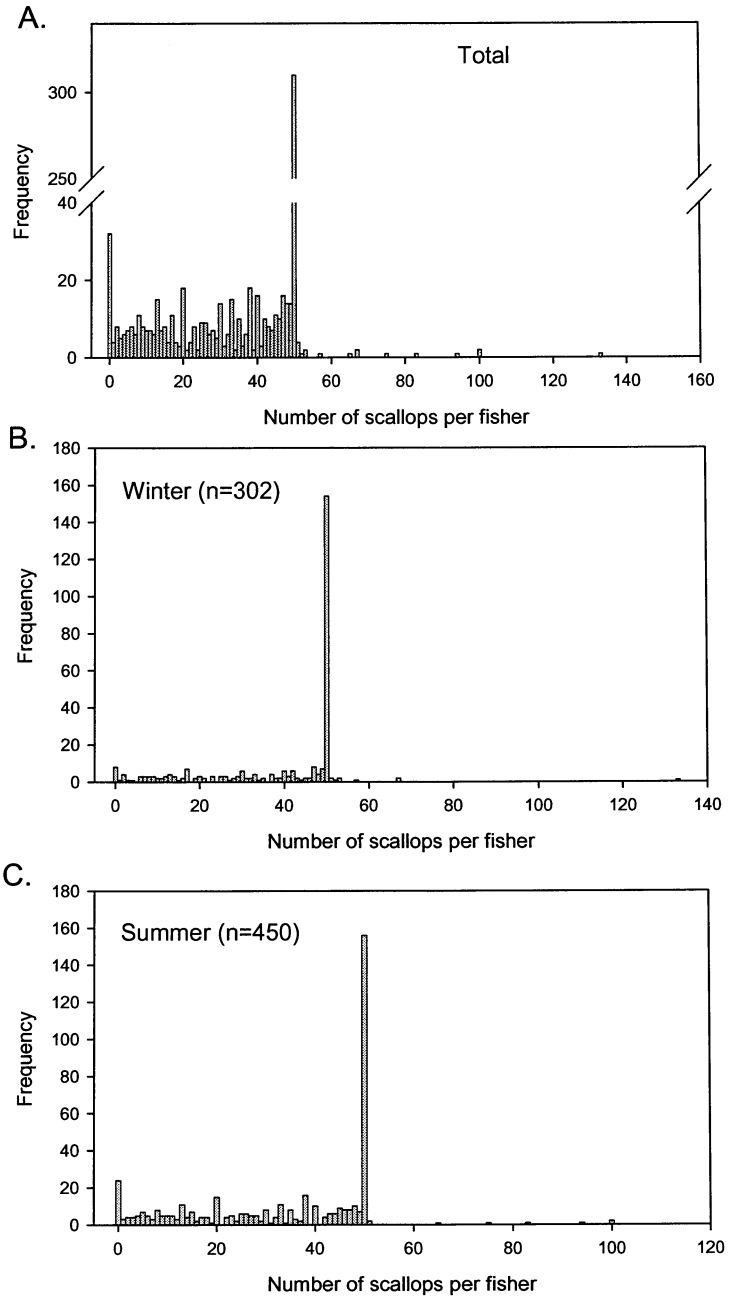

Figure 2: Frequency distributions of total catch (A), winter catch (B), and summer catch (C). Frequencies are the numbers of parties surveyed who had the plotted number of scallops per fisher.

Catches from Golden Bay included proportionally more zeroes than other bays, one extremely high catch, and a sparse distribution of sub-limit catches (Figure 3A). Tasman Bay catches contained a small proportion of zeroes and many bag limit catches; there were relatively few high catches, and an even distribution of catches through the sub-limit range (Figure 3B). Landings from Croisilles included few zero catches, a large proportion of bag-limit catches, and a higher proportion of catches of 30–50 scallops per fisher than in Tasman Bay.

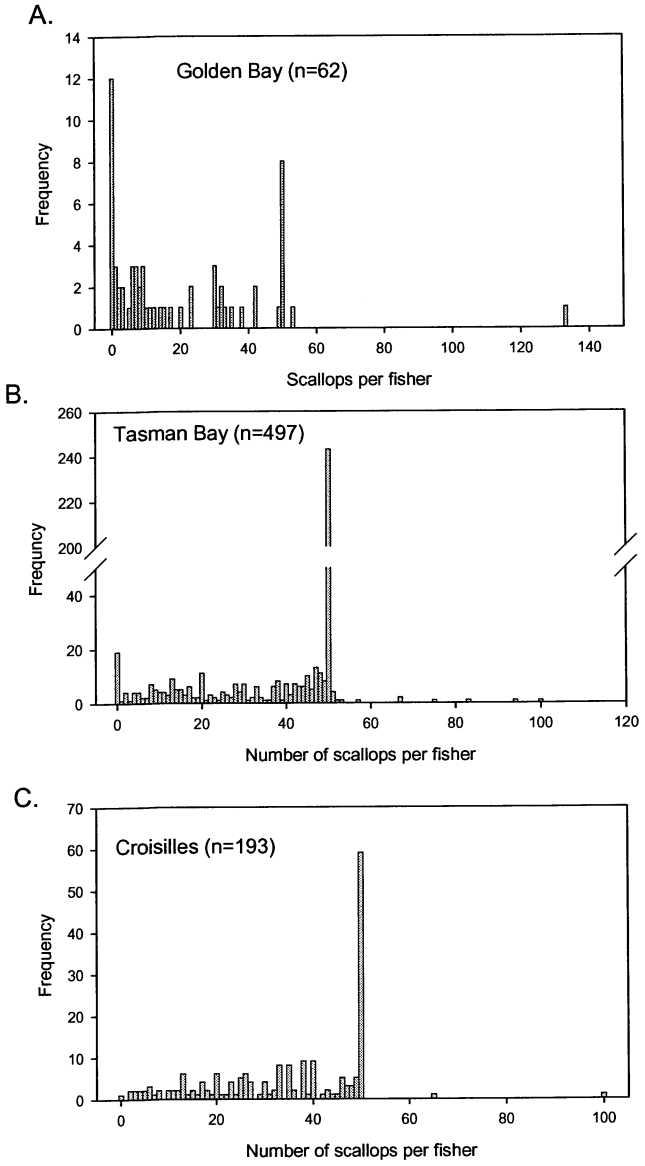

Figure 3: Catch frequencies for 3 areas: (A) Golden Bay, (B) Tasman Bay, and (C) Croisilles Harbour.

Most of the interviewed fishers had fished in central Tasman Bay (sectors E and F, between Nelson and Motueka) and in or near Croisilles (recorded as sector H in Table 5). In Golden Bay (sectors A–C), most of the interviewed fishers had fished in sector C, on the eastern side of the bay, closer to Tarakohe (Table 5).

Almost 93% of the interviewed parties across all areas had collected their scallops by dredging, 6% collected by diving, and the remainder used a mixture of the two methods. Twenty records did not supply collection method information. The use of diving to collect scallops was most prevalent in the Croisilles area, where 19% of interviewees collected by diving, and a further 2.6% used both diving and dredging; the remaining 78% of interviewees collected by dredging. In Golden Bay, all

interviewees had collected scallops by dredging only, and in Tasman Bay 97.6% of interviewees had collected scallops by dredging only. The proportion of interviewees using dredging only was slightly higher in winter (94%) than in summer (91%).

Table 5: Frequency of reported locations of catches. See Figure 1 for sectors. 22 catch records had no sector recorded.

Sector	Frequency	Percent
A	2	0.27
B	13	1.73
C	47	6.24
D	36	4.78
E	214	28.42
F	200	26.56
G	24	3.19
H	217	28.81

Ninety-six percent of interviews were of fishers using trailer boats, with very small proportions of other boat types (2% launches, 0.9% yachts).

Estimated total catches were derived as follows. We calculated a bootstrap estimate of total catch per vessel for each combination of season and bay (Table 6). We then calculated a scalar that transformed the sum of the catch to the mean catch per vessel, and multiplied the lower and upper confidence intervals of the mean catch per vessel by that scalar. Estimated total catches of scallops by area were greatest in Tasman Bay (estimated catch = 566 637), then Croisilles (221 331), and lowest in Golden Bay (72 256). Scaling these by estimated weights per scallop of 10.5 g for Tasman Bay, 11.5 g for Croisilles, and 12 g for Golden Bay gives total captured meat weights of 5950 kg for Tasman Bay, 2545 kg for Croisilles, and 867 kg for Golden Bay. Catches were larger during the winter than in the summer for all three areas (Table 6).

Table 6: Bootstrap-estimated total catches (number, and kg meat weight) by area and season, with bootstrapped 95% confidence intervals. Meat weight per scallop was assumed to be 10.5 g in Tasman Bay, 11.5 g in Croisilles, and 12 g in Golden Bay.

		Estimated catch		Estimated meat weight	
Area	Season	Number	95% CI	Weight (kg)	95% CI
Golden Bay	Winter	59 535	49 772–68 556	714	597–823
	Summer	12 721	7 299–18 926	153	88–227
Tasman Bay	Winter	321 411	296 722–346 540	3 375	3 116–3 639
	Summer	245 226	228 595–262 153	2 575	2 400–2 753
Croisilles	Winter	154 202	135 682–172 594	1 773	1 560–1 985
	Summer	67 129	60 378–74 327	772	694–855
All	Both	860 223	778 449–943 097	9 362	8 455–10 281

Estimated total number of scallops landed per ramp varied greatly among ramps (Table 7). Catches were estimated to be nil at Pohara and Tukurua in Golden Bay, and Rabbit Island in Tasman Bay. Greatest numbers and meat weights of scallops were landed at Kaiteriteri, Nelson ramp, Port Motueka, and Okiwi Bay. Within Golden Bay, the greatest number of scallops (by an order of magnitude) was landed at Tarakohe.

Table 7: Estimated catch and captured weight of scallops for ramps (with bootstrapped 95% confidence intervals), pooled across survey periods.

	Estimated catch		Estimated meat weight	
Ramp	Number	95% CI	Weight (kg)	95% CI
Golden Bay				
Collingwood	1 096	629–1 630	13	8–20
Pohara camp	0	–	0	–
Totaranui	1 404	805–2 088	17	10 – 25
Tarakohe	62 922	50 297–75 416	755	604–905
Tata Beach	6 834	5 341–8 348	82	64–100
Tukurua camp	0	–	0	–
Tasman Bay				
Kaiteriteri	179 218	166 745–191 914	1 882	1 751–2 015
Mapua	10 106	9 352–10 874	106	98–114
Monaco	4 242	3 921–4 569	45	41–48
Marahau	16 814	15 651–17 997	177	164–189
Nelson marina	24 753	22 883–26 656	260	240–280
Nelson ramp	199 151	184 203–214 364	2 091	1 934–2 251
Port Motueka	132 353	122 562–142 319	1 390	1 287–1 494
Rabbit Island	0	–	0	–
Croisilles				
Okiwi Bay	221 331	196 061–246 921	2 545	2 255–2 840

Further subdividing landings by season within ramp emphasised differences between ramps that had high winter catches and were primarily "fishing ramps" (Tarakohe in Golden Bay; Port Nelson, Nelson Marina, Port Motueka, and Okiwi Bay in Tasman Bay), and ramps with high summer catches that were essentially "holiday ramps" (Totaranui in Golden Bay; Kaiteriteri and Marahau in Tasman Bay) (Table 8).

Table 8: Estimated total number of scallops and meat weight (with bootstrapped 95% confidence intervals) landed by recreational fishers at each surveyed ramp in summer (S) and winter (W). Percentage of the catch taken during the summer at each ramp is also shown.

		Estimated catch		Estimated meat weight		%
Ramp	Season	Number	95%CI	Weight (kg)	95% CI	summer
Golden Bay						
Collingwood	W	0	–	0		100
	S	1 096	629–1 630	13	8–20	
Pohara camp	W	0	–	0	–	–
	S	0	–	0	–	
Totaranui	W	0	–	0	–	100
	S	1 404	805–2 088	17	10–25	
Tarakohe	W	54 122	45 247–62 324	649	543–748	14
	S	8 800	5 049–13 092	106	61–157	
Tata Beach	W	5 412	4 525–6 232	65	54–75	21
	S	1 422	816–2 116	17	10–25	
Tukurua camp	W	0	–	0	–	–
	S	0	–	0	–	
Tasman Bay						
Kaiteriteri	W	35 445	32 722–38 216	372	344–401	80
	S	143 774	134 023–153 698	1 510	1 407–1 614	
Mapua	W	7 701	7 109–8 302	81	75–87	24
	S	2 406	2 242–2 572	25	24–27	
Monaco	W	3 726	3 440–4 017	39	36–42	12
	S	516	481–552	5	5–6	
Marahau	W	2 484	2293–2678	26	24–28	85
	S	14 330	13 358–15 319	150	140–160	
Nelson marina	W	21 239	19 608–22 900	223	206–240	14
	S	3 513	3 275–3 756	37	34–39	
Nelson ramp	W	160 198	147 892–172 723	1 682	1 553–1 814	20
	S	38 953	36 311–41 642	409	381–437	
Port Motueka	W	90 618	83 657–97 703	951	878–1 026	32
	S	41 735	38 905–44 616	438	409–468	
Rabbit Island	W	0	–	0	–	–
	S	0	–	0	–	
Croisilles						
Okiwi Bay	W	154 202	135 682–172 594	1 773	1 560–1 985	30
	S	67 129	60 378–74 327	772	694–855	
All	Both	860 223	778 449–943 097	9 362	8 455–10 281	

4.2 Times of landing

There was no clear trend in catch per vessel over the day, when the entire dataset was examined (Figure 4).

When subdivided by location and season, the plots emphasised the higher catches in winter than in summer, and the much lower catches in Golden Bay than elsewhere (Figure 5). Landings were too small to reliably interpret diel patterns (Figure 5).

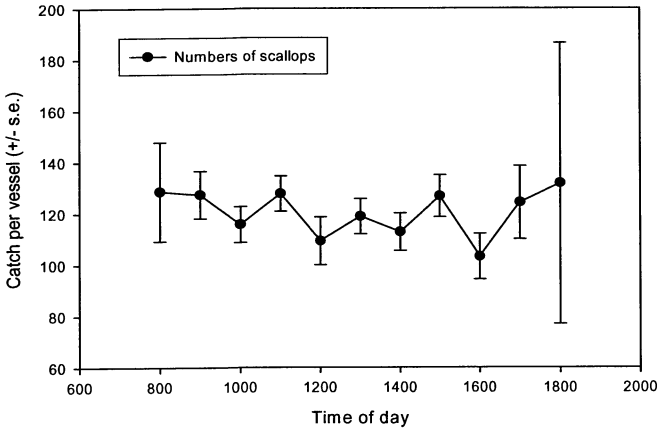

Figure 4: Mean catch per vessel (pooled across all localities and both seasons) vs time (in hourly intervals). Sample size varies among times.

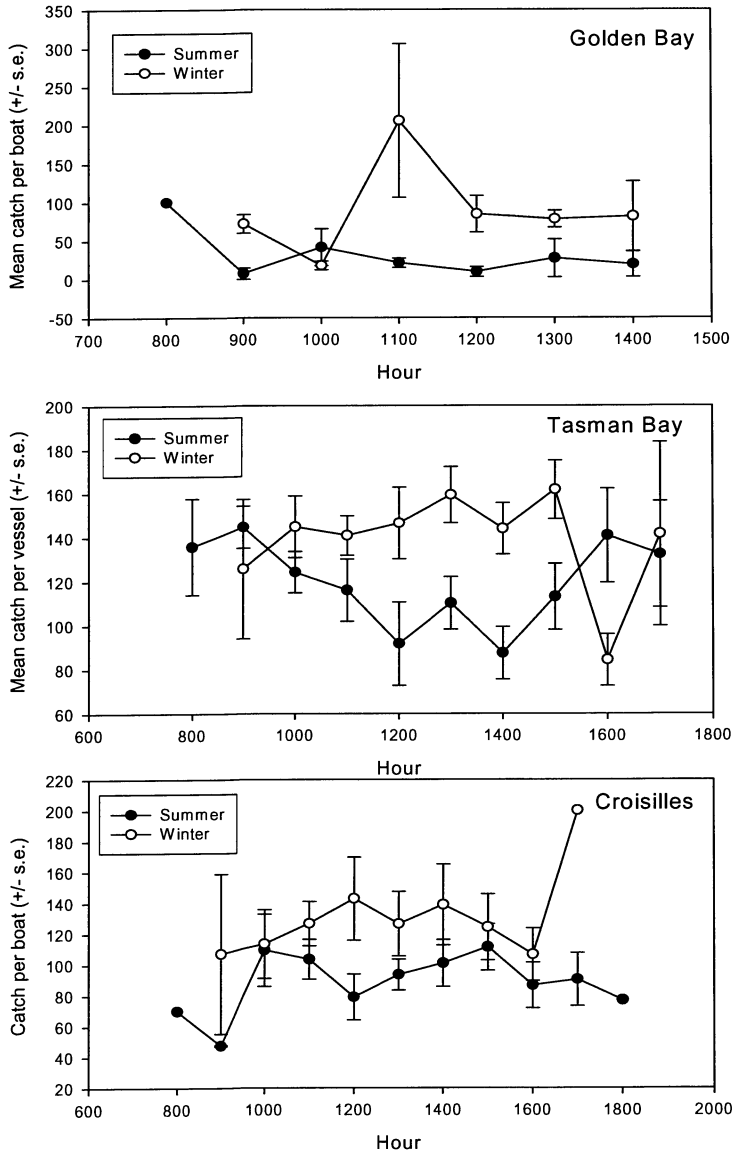

Figure 5: Hourly catch rates in summer and winter for Golden Bay, Tasman Bay, and Croisilles Harbour.

4.3 Scallop size

Size comparisons among locations were hindered because many of the Croisilles scallops (and possibly some from Tasman and Golden Bays) appeared to have been measured with a bias towards measurements divisible by 5 (Figures 6, 7, and 8). Tasman Bay and, particularly, Croisilles Harbour scallops had sharp size distribution cutoffs at the 90 mm lower legal size limit, whereas more sub-legal individuals were taken in Golden Bay. Scallops from Croisilles Harbour had slightly greater mean sizes (96.8 and 97.4 mm in winter and summer, respectively) than at the other localities (94.8 and 93.7 mm in winter and summer in Tasman Bay, and 94.6 and 93.8 mm in winter and summer in Golden Bay).

The proportions of undersized scallops taken were consistently lowest at Croisilles (1.5% in winter, 0.6% in summer), 6.5% for winter in Tasman Bay and 9% for summer in Tasman Bay, and 11% for winter in Golden Bay, and nearly 15% for summer in Golden Bay.

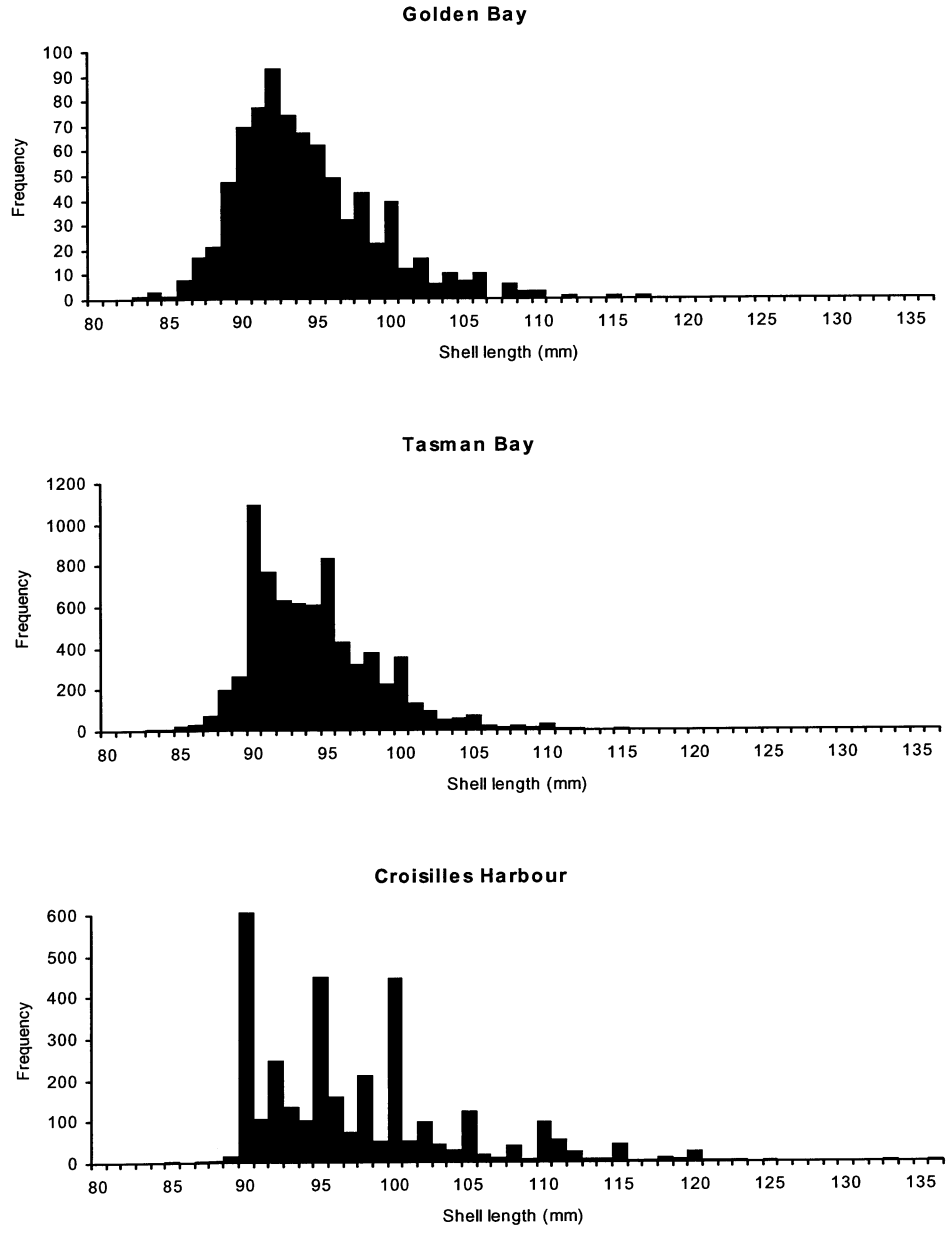

Figure 6: Size frequency distributions for Golden Bay, Tasman Bay, and Croisilles Harbour, pooled across seasons.

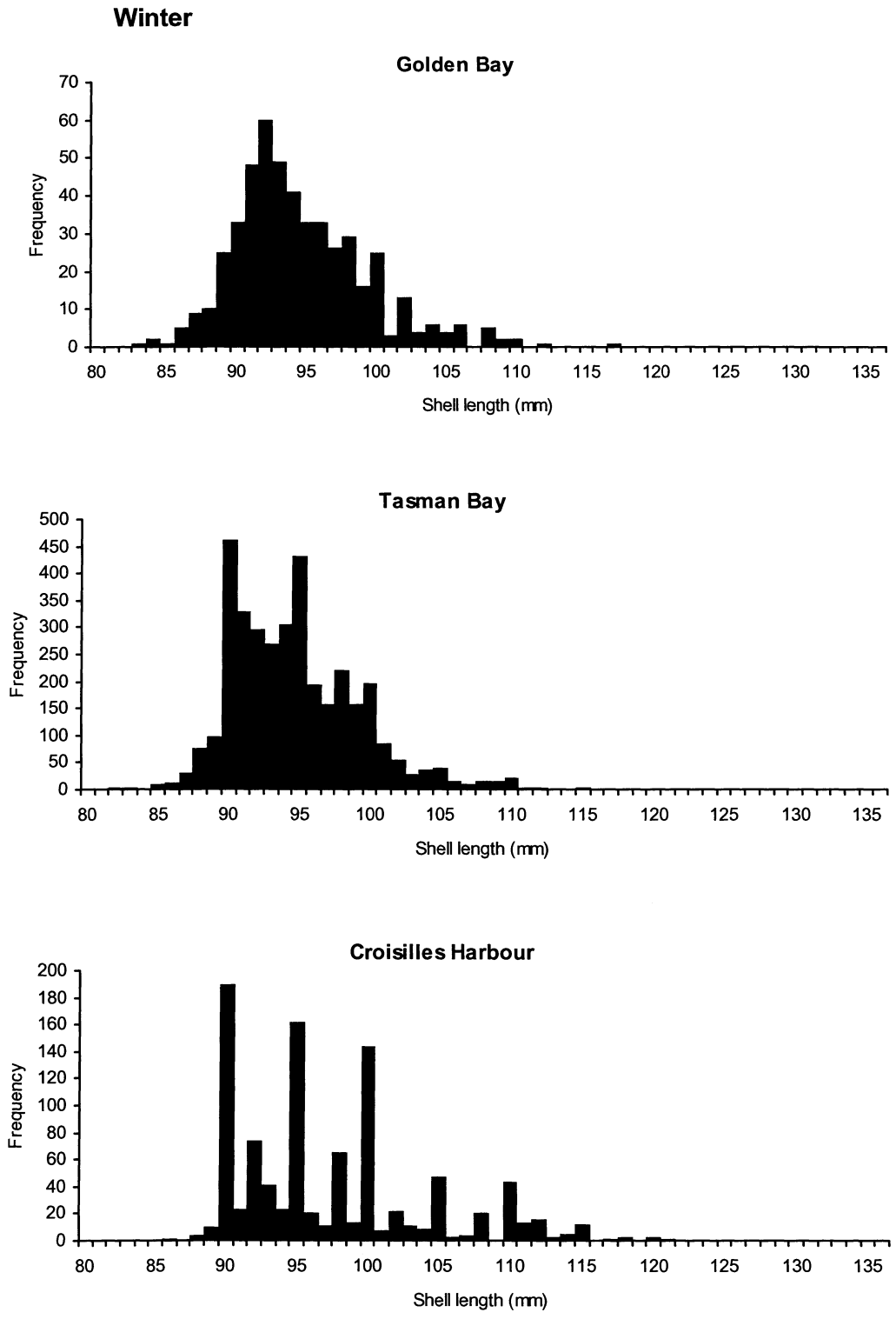

Figure 7: Size frequency distributions for Golden Bay, Tasman Bay, and Croisilles Harbour, in winter.

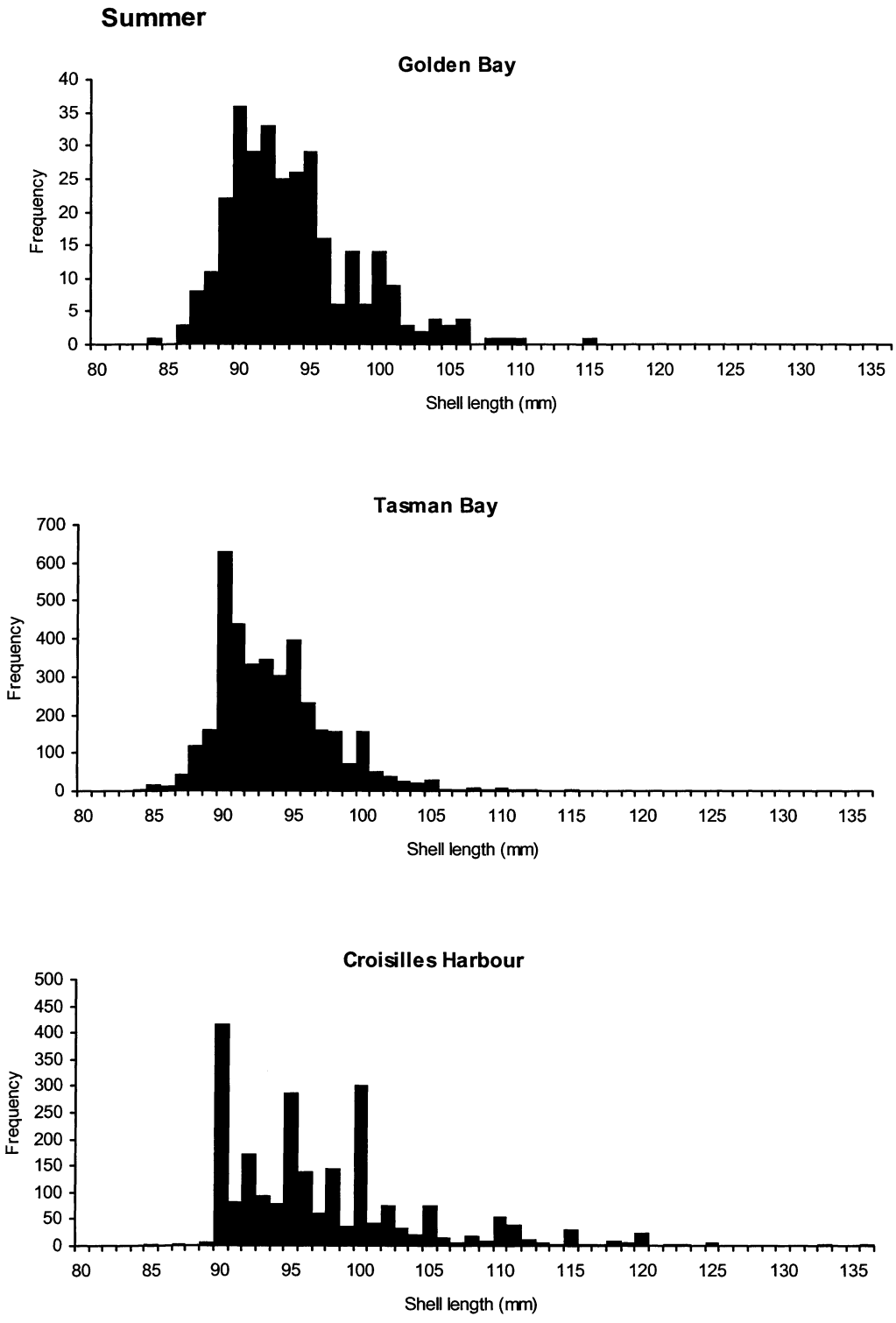

Figure 8: Size frequency distributions for Golden Bay, Tasman Bay, and Croisilles Harbour, in summer.

4.4 Weather variables

Total scallop catch per session was plotted in relation to sea condition (Figure 9), and other weather variables, but the correlations were small, for individual variables, for principal components that summarised the weather variables (not presented), and for combinations of weather variables in GLM-type models (not presented). Further post-stratification of the analysis by ramp, season, and daytype

(weekend vs weekday) failed to show clear relationships with any variable, with the strongest Pearson correlations being those of sea condition with mean scallop catch (0.116) and oyster catch (0.112), and of mean oyster catch with windspeed (0.119).

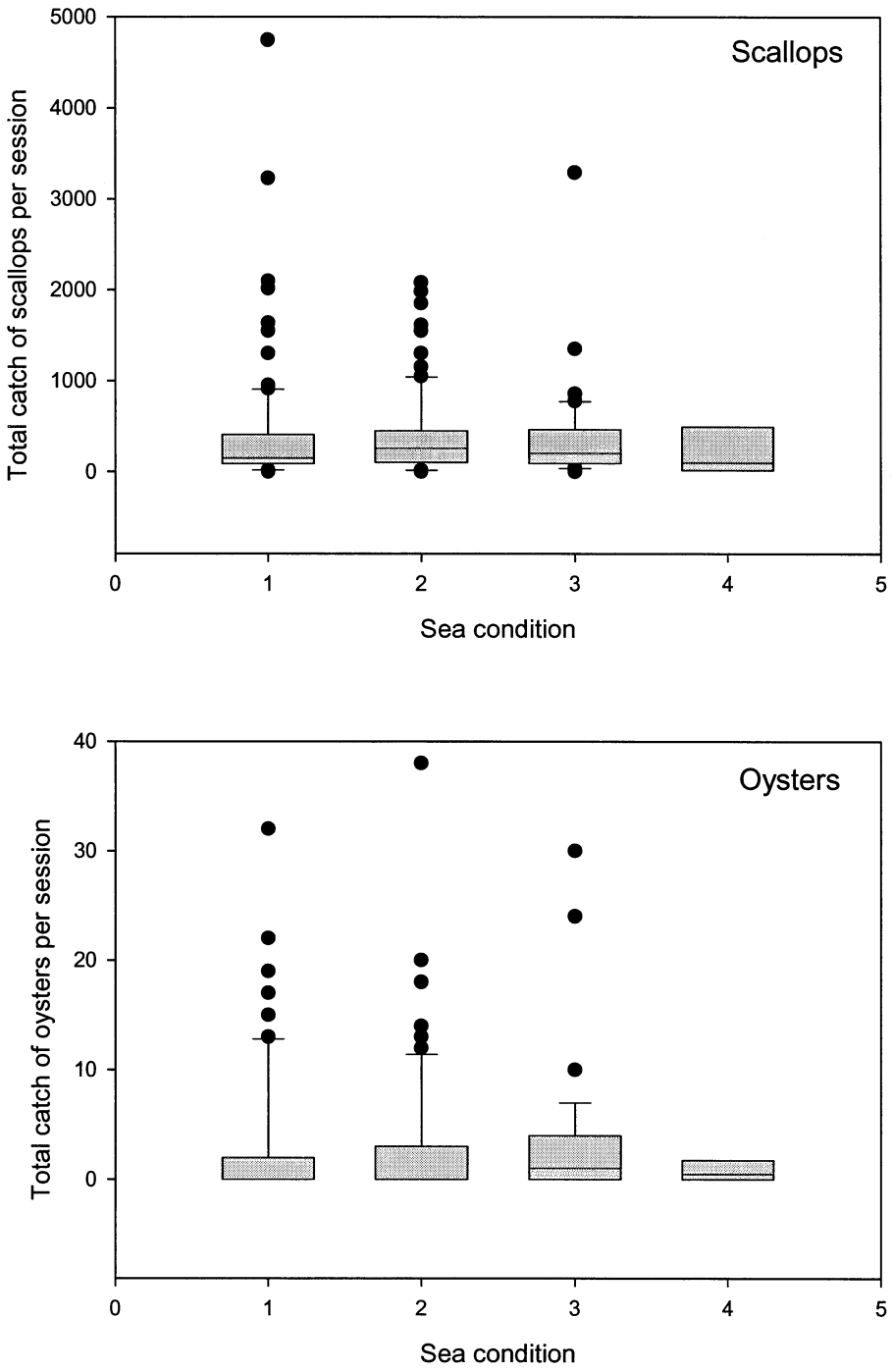

Figure 9: Total catches of scallops and oysters per session in relation to sea condition. Broad shaded bars bound the 25th and 75th percentiles, horizontal line within shaded bar indicates median, whisker extends to 95th percentile, and individual values lying beyond that are indicated by dots.

4.5 Oysters

Catches of oysters were much lower than those of scallops, averaging less than one per vessel per ramp across seasons (Table 9). No oysters were taken in Croisilles Harbour, and very few were recorded from Golden Bay. Most were taken from Tasman Bay, with Kaiteriteri, Port Motueka, and Nelson ramp having relatively high landings. The size distribution of harvested oysters was roughly normal, with a mean at about 80 mm (Figure 10).

Table 9: Estimated total catch (Number) of oysters harvested in the three main areas, and by ramp, in summer and winter (with 95% confidence intervals).

Area/Ramp	Summer		Winter		Overall	
	Number	95% CI	Number	95% CI	Number	95% CI
Golden Bay	167	0–400	44	0–116	210	0–516
Tasman Bay	2 963	2 107–3 984	2 627	1 713–3 814	5 590	3 821–7 798
Croisilles	22	0–77	0	–	22	0–77
Collingwood	14	0–34	0	–	14	0–34
Totaranui	18	0–44	0	–	18	0–44
Tarakohe	115	0–277	40	0–106	155	0–382
Tata Beach	19	0–45	4	0–11	23	0–55
Kaiteriteri	1 737	1 236–2 336	290	189–420	2 027	1 425–2 756
Mapua	29	21–39	63	41–91	92	62–130
Monaco	6	4–8	30	20–44	37	24–53
Marahau	173	123–233	20	13–29	193	136–262
Nelson marina	42	30–57	174	113–253	216	143–310
Nelson ramp	471	335–633	1309	854–1 900	1 780	1 189–2 533
Rabbit Island	0	–	0	–	0	–
Port Motueka	504	359–678	741	483–1 075	1 245	842–1 753
Okiwi Bay	22	0–77	0	–	22	0–77

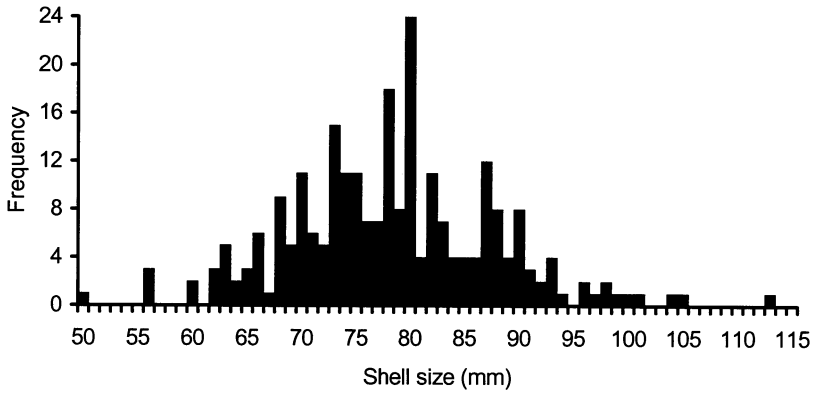

Figure 10: Unscaled size distribution of oysters taken by recreational fishers, pooled across all combinations of sampling variables (bays, seasons). Size is the mean of length and width. *n* = 250.

As catches of oysters were much smaller than those of scallops, and insufficient data were obtained to detect patterns in the numbers of scallops taken with environmental variables, no further analysis of oyster catches was undertaken.

5. DISCUSSION

This report presents the results of the first comprehensive survey of recreational fishing for scallops and dredge oysters in Tasman and Golden Bays. All the primary access points, and numerous secondary access points, were surveyed for the duration of the 2003–04 recreational fishing season. However, it is acknowledged that the final estimate of catch is still likely to be an underestimate for the following reasons.

- Some fishing may not have terminated at a boat ramp, e.g., shore-based diving, or scalloping from a small boat launched and retrieved at a beach.
- Some fishing may have terminated at seldom-used (and unsurveyed) ramps, e.g., Paton's Rock, Tapu Bay.
- Some fishing of the Tasman Bay resource may have terminated at ramps or marinas in the Marlborough Sounds or Wellington.
- Illegal fishing is less likely to occur at the accessible times and places where sampling occurred.
- Some scallops are undoubtedly eaten at sea.

Nevertheless, the estimated total catch of 903 000 scallops, with an estimated meatweight of 11.0 t is believed to be the best estimate yet available from this recreational fishery. It is lower than any of the estimates obtained from previous surveys (Table 10). The estimate was expected to be low for several reasons. First, the pre-season scallop dredge survey conducted in May–June 2003 by the Challenger Scallop Enhancement Company indicated that recruited scallop biomass was at a low level relative to recent previous surveys (see Table 10). Second, the comparable survey conducted in May–June 2004 indicated that natural mortality of scallops had been exceptionally high between the 2003 and 2004 surveys, i.e., the reduction in biomass between the surveys was much greater than the commercial catch (Challenger Scallop Enhancement Company, unpubl. results). Third, recreational scallop fishers, particularly those in Golden Bay, were stating, from early in the season, that scallops were scarce relative to previous seasons. There is a positive relationship between the pre-season dredge survey estimate of recruited biomass, and the estimated recreational catch in the subsequent season (see Table 10). The estimated recreational catch in 2003–04 of about 860 000 scallops can be considered the best estimate available from a poor season, particularly so in Golden Bay.

Table 10: Recreational survey estimates of numbers of scallops harvested in Tasman and Golden Bays, with coefficients of variation (c.v., %), and relative biomass estimates of recruited meatweight biomass (Biomass, t) from dredge surveys conducted by the Challenger Scallop Enhancement Company prior to the recreational surveys. –, estimate not available.

	Recreational survey			Dredge survey
Year	Number	c.v.	Reference	Biomass
1992–93	1 456 000	21	Tierney et al. 1997	–
1996	1 680 000	15	Bradford 1998	950[#]
1999–2000	3 391 000	20	R. Boyd unpubl. results	1 173
2000–01	2 867 000	14	R. Boyd unpubl. results	960
2003–04	860 000	10	Current study	788

[#] Survey estimate scaled up to account for unsurveyed area

Oyster catches were low. The seasonal shift to oysters in Golden Bay (more taken in summer) may reflect fishers adopting oysters as a primary target, having abandoned scallops because of the low catch rates in Golden Bay. Because of the low catches, little comment can be made regarding the fishery for oysters; they appear to be mainly taken as incidental bycatch of scallop fishing, on the western side of Tasman Bay.

The poor season for scallops in Golden Bay may have been responsible for the high proportion of undersized scallops in catches there. The very low take of undersized scallops at Croisilles Harbour

may have stemmed from the knowledge that catches would be inspected at the launching ramp. Tasman Bay and Croisilles provided many limit bags. The lower catches in summer may represent depletion of stocks during the season, or greater representation of uninformed (either lacking fishing skill or knowledge of where scallops were) fishers in the fishery during summer.

The fishery in all three bays was dominated by trailer boats. Shallower depths, shorter travel distances, and thus access to scallops from smaller vessels allow a greater participation of divers at Croisilles than at Tasman Bay. Years in which there was a high proportion of strong northerly winds would be expected to have reduced recreational catches, because of reduced numbers of boats going out. The lack of correlation of catch with weather variables was surprising; we offer these possible explanations: (i) variation in sampling effort due to holidays etc. overwhelms variation in weather; (ii) less able fishers may venture out on better days (in holiday periods etc.), and thus dilute the simple effects of weather; (iii) the range of weather conditions sampled appears to have been relatively small, and it may be that there was insufficient variation to detect an effect.

6. ACKNOWLEDGMENTS

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Appendix A: Interview record sheet.

RECREATIONAL SCALLOP FISHERY BOAT SURVEY FORM
SESSION & BOAT INFORMATION

Page ....of........

Interview location: ______________________ Interviewer name: ______________________

Interview location code	Date (d d m m y y)	Session time start (24 hour)	Session time finish (24 hour)	Day type	Interviewer Initials

Session 1=am, 2=pm

Day type: 1=Weekend or Public holiday, 2=Weekday

Environmental data:

Sea conditions	Rain	Overhead conditions	Wind speed	Wind direction

Sea conditions:
1=Smooth (0.1 - 0.5m)
2=Slight (0.5 - 1.0 m)
3=Moderate (1.0 - 2.5m)
4=Rough (2.5 - 4.0m)

Rain:
1=Nil
2=Light scattered
3=Light continuous
4=Medium scattered
5=Medium-heavy

Overhead conditions:
1=Sunny continuous
2=Mainly sunny
3=Mainly cloudy
4=Continuous cloudy

Wind speed:
1=Nil
2=Light (1-10 kts)
3=Medium (11-20 kts)
4=Strong (21 + kts)

Wind direction:
1=Nil (no wind)
2=Variable
3=North
4=South
5=NorthEast
6=SouthWest
7=East
8=West
9=SouthEast
10=NorthWest

Boat data:

Boat No.	Boat type	Intercept outcome	Time of Intercept (24 hour)	No. of fishers	Fishing method	No. of scallops	Counted	Measured	No. of oysters	Counted	Measured	Fishing location	Notes

Appendix B: Cross tabulations of numbers of fishers and other variables, and summary statistics.

		Number of fishers					
Variable	Variable category	1	2	3	4	5	≥6
Fishing method	Diving	3	14	13	13	3	1
	Dredging	14	213	207	161	70	36
	Mix	0	2	2	2	1	0
Sector	A	0	0	1	1	0	0
	B	0	4	6	2	1	0
	C	2	22	14	8	0	1
	D	1	10	18	4	1	2
	E	4	68	52	50	30	10
	F	3	51	62	48	25	11
	G	0	10	4	7	2	1
	H	0	1	2	0	1	1
	Croisilles	7	61	63	56	14	11
Bay	Golden Bay	2	26	21	11	1	1
	Tasman Bay	9	143	142	117	60	29
	Croisilles	6	60	60	48	13	7
Ramp	Collingwood	1	1	1	3	0	0
	Totaranui	0	1	2	1	0	0
	Tarakohe	1	22	18	7	1	1
	Tata Beach	1	3	3	2	0	0
	Kaiteriteri	1	55	44	42	20	12
	Mapua	0	2	1	1	0	1
	Monaco	0	3	1	0	0	0
	Marahau	1	5	5	3	2	1
	Nelson marina	0	4	4	3	3	3
	Nelson ramp	6	48	59	46	25	11
	Port Motueka	0	26	26	20	10	3
	Okiwi Bay	6	59	59	48	13	5
Ramp type	Non-tidal	14	216	211	167	72	36
	Tidal	3	13	12	9	2	1
Season	Summer	10	144	132	100	45	22
	Winter	7	85	91	76	29	15
Day type	Weekend/Holiday	13	157	162	142	53	27
	Weekday	4	72	61	34	21	10
Session	Morning	12	102	103	68	29	10
	Afternoon	5	127	120	108	45	27
Vessel	Charter	0	0	0	0	0	1
	Launch	0	2	6	5	2	1
	Customary permit	0	1	2	0	0	0
	Trailer boat	17	222	215	170	71	34
	Yacht	0	4	0	1	1	1
Mean, scallops per fisher		45.3	37.2	36.0	36.6	35.9	29.4
SD, scallops per fisher		9.4	18.3	19.4	17.4	16.0	18.7
Mean, oysters per fisher		0.7	0.5	0.3	0.2	0.1	0.2
SD, oysters per fisher		2.0	2.0	0.8	0.5	0.4	0.8