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EXECUTIVE SUMMARY

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This report addresses two objectives within the Ministry of Fisheries project REC1999/02:

1. To establish the methodology for estimating the recreational harvest of paua, rock lobster, and other species in the Maketu Taiapure on an on-going basis.
2. To train local volunteers in survey data collection and analysis to maintain on-going monitoring of the recreational harvest in the Maketu Taiapure.

The Maketu Taiapure is on a northeast facing coast and comprises 60 km of open ocean shore centred on Okurei Point, from Wairakei (Papamoa) in the west to Otamarakau in the east. The outer boundary of the Taiapure is 1000 m offshore, except at Okurei Point where it is 3000 m. Also included are the Little Waihi and Maketu Estuaries that lie east and west of Okurei Point respectively.

Fishing activity in the various parts that make up the Maketu Taiapure could be observed from a small number of lookout points, leading to satisfactory estimates of fishing effort. The Taiapure was divided into nine fishing areas. The fisher counts in all areas except Little Waihi Estuary averaged less than 10 and rarely exceeded 20. Over 100 fishers (mainly handgathering) were observed on some days in Little Waihi Estuary, with a summer weekend average of almost 50. The Groyne, where the Kaituna River was diverted to flow directly into the sea rather than through the Maketu Estuary, had fishers almost all the time. These fishers mainly caught kahawai.

The diverse nature of the fishing opportunities available in the Taiapure, from shellfish gathering in the estuaries to whitebaiting in canals to open water line fishing and diving, made it difficult to achieve enough interviews of fishing outcomes to be able to attach much certainty to harvest estimates. The fisher numbers on any one day were too low to make a reliable estimate of mean harvest rate for finfish for that day even if all fishers could be interviewed, and for some species (for example, snapper) there were not enough interviews altogether to make reliable estimates of mean harvest rate.

The recreational harvests were estimated by multiplying the counts of fishing activity (by method) in a location by a mean harvest rate or mean harvest. The observer counts were stratified by season (summer and winter) and day type (weekend and weekday) and harvest estimates used stratum means of fisher counts but the mean harvest rate or mean harvest was calculated from all the interview data. Another factor, the fisher "turnover" or the length of the fishing day, was needed for the estimates and a range of values from the likely minimum to the likely maximum was used.

Harvests by recreational fishers of paua and rock lobster in the Taiapure appear to be small. Much more significant are the annual harvests of pipi (one or two million), cockles and mussels (tens of thousands), and kahawai (between 16 and 59 t). There are suggestions that the shellfish harvests by fishers using customary permits are larger than the recreational harvests.

This was the most detailed survey of marine recreational fishing in New Zealand waters carried out to date and very labour intensive. Despite this, the low fisher numbers and other uncertainties resulted in imprecise estimates of harvests. More information on fisher turnover by locality and time would have improved our harvest estimates. Intensive volunteer surveys such as this require very capable organisers who have a good understanding of sampling strategy and who should probably be paid.

1. INTRODUCTION

This report forms part of a two-year study to establish methods for local volunteers to use to determine the annual recreational harvest in the Maketu Taiapure. Approaches found to be useful in this area will be incorporated into a broader manual of methods that can be used by other local communities to estimate their recreational harvest.

This work was carried out as part of Ministry of Fisheries project REC1999/02. The overall objective of the project was to provide a means of estimating the recreational harvest in Maketu Taiapure on an on-going basis.

The specific objectives addressed in this document were the first two of three. (The third concerns documenting the methodologies for use by other local communities.)

1. To establish the methodology for estimating the recreational harvest of paua, rock lobster, and other species in the Maketu Taiapure on an on-going basis.
2. To train local volunteers in survey data collection and analysis to maintain on-going monitoring of the recreational harvest in the Maketu Taiapure.

Okurei (Town) Point and its environs, in the Bay of Plenty, supports important recreational and customary fisheries for shellfish and finfish. Early in 1998 this area became the Maketu Taiapure, recognising the significance to local Maori of the kai moana. There was no information on the size of the recreational harvest in the Taiapure. Paua, green mussel, tuatua, kina, rock lobster, tarakihi, snapper, and kahawai were thought to be the main species in open waters. Pipi and cockles were the main shellfish taken in the estuaries and there were probably also small catches of finfish. The Maketu Taiapure Committee of Management (Maketu Taiapure CoM) required more detailed information on species and harvests to develop appropriate management plans and for on-going monitoring of management initiatives.

The Maketu Taiapure is on a northeast facing coast and comprises 60 km of open ocean shore centred on Okurei Point, from Wairakei (Papamoa) in the west to Otamarakau in the east (Figure 1). The area is part of a largely rural setting, with the nearest major urban population 30 km further west at Tauranga. Currently, the outer boundary of the Taiapure is 1000 m offshore, except at Okurei Point where it is 3000 m. What exists now is the first stage of three planned for this Taiapure: the next is extension of the Taiapure further offshore, to the 10 fathom (about 20 m) depth contour; and the last has all waters to Motiti, Motuhaka, and Motunau Islands included.

The recreational fishery is based on day trips and has four fairly discrete components. The first is Okurei Point, where the reefs are fished mainly from boats that are launched near the mouth of the Kaituna River and in the Maketu and Little Waihi Estuaries, and from a small number of boats arriving from outside the Taiapure. Boat fishing may include use of lines, nets, rock lobster pots, and scuba. Vessels mostly range from dinghies to 7 m runabouts on trailers but there are a few, larger moored boats in the Kaituna River. Access difficulties mean there is little shore fishing around Okurei Point, except at Newdick's Beach (between Okurei Point and the mouth of the Little Waihi Estuary) where there is handgathering, line fishing, and scuba and snorkel diving. Officially, a rahui was in place at Newdick's Beach throughout the survey period, but it proved unenforceable.

Stretching about 30 km to the northwest and southeast of Okurei Point is the second component of this fishery, that associated with uninterrupted open sandy beaches. Most fishing is surf-casting and use of kontiki long-lines, but there is also shellfish harvesting from the low intertidal area.

The third component is the estuarine fisheries of the Maketu and Little Waihi Estuaries. There was a rahui on shellfish collection in the Maketu Estuary from before the start of this project in October 1999 until mid 2000.

The fourth component is the Groyne at the mouth of the Kaituna River. The Kaituna River used to flow into the Maketu Estuary but was diverted to flow directly into the sea in 1957–58 via a channel. A groyne built on the eastern bank of the mouth of this channel, with road access, provides a convenient and popular fishing place. This small area is considered separately as it has fishers more or less continuously. These fishers mainly target kahawai. (Table 1 contains the common and scientific names of the species mentioned in this report.)

Te Arawa maintain kaitiakitanga over the seafood of this shore and they are deeply concerned about its sustainability. The sampling strategy used in this study was developed in close consultation with the iwi through the Maketu Taiapure CoM, with the local honorary fisheries officer, and with other key local individuals. The methodology adopted involved fisher counts from key observation points to provide information on fishing effort, and boat ramp interviews and roving interviews to obtain information on catches including what was caught, harvest rates, and fishing times. This catch and effort information would then theoretically allow estimates of annual recreational harvests. Although the contract specified determining only recreational catches, it was decided in consultation with the Maketu Taiapure CoM that customary catches would also be recorded. Recreational fishing was defined as fishers fishing for individual reasons and purposes; customary as fishing with a customary permit; commercial as fishing with commercial quota with catches recorded on Ministry of Fisheries databases; and illegal as fishing for sale without permit. Recreational species included all species taken alive for whatever reason, whether or not the species was in the QMS, but not taken under permit and/or quota. Sometimes the recreational harvest might include animals less than the minimum legal size or in numbers exceeding the daily limit, but these were still to be recorded. It was not possible for observers to distinguish recreational and customary effort, but the scale of any customary fishing would be determined from the interviews. On the other hand, commercial effort would be recognisable by the observers: one commercial rock lobster boat fished Okurei Point and one or two others occasionally set nets in Little Waihi Estuary.

As required by the contract, we discussed our proposed methods (data recording forms, survey design, etc.) with the Ministry of Fisheries before sampling began and we also kept them aware of progress as we went along. At the October and November 1999 meetings with the Maketu Taiapure CoM, and after the first month of sampling (December 1999), it became clear that both the specific objectives listed above could be met simultaneously. This approach, different from what was originally contracted, was accepted by the Ministry of Fisheries. Data collected were entered directly on to forms and later into a database at Taiapure office in Maketu from which the Maketu Taiapure CoM could draw summaries. This helped fulfil the requirement of the contract to provide regular feedback to the Maketu Taiapure CoM. NIWA staff also regularly met with the CoM during the project.

The day-to-day management of the survey was in the charge of the Maketu Taiapure CoM. Local volunteers carried out the observations and interviews and received a small payment to cover such things as travel costs. A computer was provided and local volunteers entered the data from the observer and interview forms into an Access database specially constructed for this project.

The data analysed in this report cover a full year, the 2000 calendar year although fisher count and associated data for December 1999 are also shown. The data are stratified by season (summer: January to April inclusive and December; and winter: May to November) and day type (weekends: weekends, holidays, and all days between Christmas and New Year; and weekdays: all other days) Interviewing stopped at the end of January 2001 but observer data, at least at weekends and public holidays, continued to be taken until the end of September 2001; these additional data are held by the Maketu Taiapure CoM.

2. METHODS

Fisher counts depended on observers being able to sight and record fishers. The Maketu Taiapure covers the coastlines on either side of Okurei Point, an estuary on either side of the point, reefs extending out from the point, and the Kaituna River mouth (see Figure 1). The elevation of Okurei Point (about 60 m) allowed observers using high-powered, Tasco zoom binoculars and a tripod-mounted, Kenko GF63 spotting scope to scan much of the Taiapure for fishers and fishing equipment (e.g., buoys). Moored buoys were set using GPS to define the 3000 m mark around Okurei Point; the most eastern and most western of these buoys were 1000 m off the beach, which gave a reference point for the observers looking for Taiapure fishing off these beaches (although little or no boat fishing was expected within 1000 m of the beaches). To the west of Okurei Point, the Kaituna River runs almost parallel to the coast for several kilometres blocking easy access to the coast; consequently little shore fishing was observed west of the river mouth. Fishing activity in the estuaries was visible from suitable vantage points.

Interviews were conducted at boat ramps and at fishing sites. There are access points to the coast, at intervals, along the beaches east of Okurei Point. The use of motor vehicles on all of these beaches is strongly discouraged by the Maketu Taiapure CoM and others in the community. This had a bearing on the way that fisher interviews could be conducted because interviewers could not drive along beaches to reach fishing parties; instead it was agreed that only fishing parties within easy walking distance of the road ends would be interviewed. Although many boats, mainly from Tauranga and Mount Maunganui, fished waters offshore of the Taiapure, it seems few of these fished inside the Taiapure.

2.1 Fisher counts

An observation was a detailed snapshot by an observer of all fishing activity taking place in a particular area. The main lookout point was Okurei Point, LP1, from which fishers in localities KR1, MB1, OP1, OP2, PB1, and PB2 could be counted (see Figure 1 and Table 2 for definitions). The observer systematically observed and recorded all fishing parties and the number of individual fishers within each party. The estuaries were not visible from LP1 and had separate lookout points, LP2 for Maketu Estuary (ME1) and LP3 for the Little Waihi Estuary (WE1). Fishing activity on the far eastern coast of the Taiapure (OB1) could not be detected from LP1 and so a fourth lookout point was chosen, but a willing observer for this remote lookout point was not available. Observations were scheduled for all weekend and holiday days, and for Tuesdays and Thursdays and had to be during daylight hours so that fishers could be seen. During analysis, all days between Christmas and New Year were designated as holidays. Two observation times were given for LP1, one random and the other in the late afternoon when after-work fishers might appear. The random times were selected from 0730, 0830, ... , 1730 (1630 in winter), with any of these times equally likely. The two estuaries were observed around low tide occurring during daylight hours so that fishers handgathering shellfish would be counted. Observers had some latitude to modify the observation time as the time of low tide is not easy to predict for small estuaries. Observers counted the numbers of fishers in a fishing party in each locality and their fishing methods. They also described the environmental conditions in several categories.

Copies of the Instructions to Observers and the observer recording forms are given in Appendix 1. These were developed in consultation with the Maketu Taiapure CoM and were based on and consistent with other Ministry of Fisheries recreational fishing forms. A sample of the prescribed observation times is given in Appendix 2.

The observer data were stratified by day type (weekends/holidays including all days between Christmas and New Year and week days) and by season. The seasons were determined after preliminary examination of the data and were defined as summer (December to April inclusive) and

winter. The analyses use data from the 2000 calendar year and the summer stratum is split into two portions, January to April and December.

The fishing effort (in hours) in a stratum, E_i, was estimated by multiplying the mean number of fishers, $\overline{F}_i$, in a stratum by the number of days, d_i, in a stratum (Table 3) and the assumed number of fishing hours in a day, e_i. The annual totals of fishing effort, E, were obtained by summing the stratum totals.

$$E = \sum_i E_i = \sum_i \overline{F}_i d_i e_i$$

The methods suggested for analysing surveys of this type contain a "probability of fishing" factor (Pollock et al. 1994, chapter 15). This factor has been interpreted here as the available fishing time or the mean number of fishing hours in a day in the stratum, e_i. However, e_i is unknown and results using several assumptions are made, either the mean day length in a stratum, or the mean day length modified by a cosine function with maximum at the longest day and minimum at the shortest day, or an assumed average fishing time. We originally considered using fisher numbers and the actual day length on the day observations were made, but changed to using stratum mean values because of potential problems arising from missing observer sessions, especially in winter. In some harvest estimates, the estimate of the total number of fishers in a stratum, $\overline{F}_i d_i$, was first calculated and then multiplied by a fishing time and a "turnover" factor. That is, while each fisher might fish for 3–4 h, during the day they might be replaced by perhaps three other fishers and so the turnover factor would be three.

Mean fisher numbers, $\overline{F}_i$, their standard error, and hence the coefficient of variation (c.v.) were estimated using the standard formula (similar to those given in Appendix 5, see later).

Missing observations lead to some uncertainty (possible bias) in the mean fisher numbers, $\overline{F}_i$. Two assumptions were made; one assumed that the raw mean value applied to all days in the stratum and the other that no fishing took place on the designated observation days on which no observations were made. The rationale for the second assumption is that most of the missing observations occurred during winter when the weather might be expected to deter fishers (and perhaps observers).

The fishing methods (see Table 1) were simplified from those used in the North region and in the 1996 national survey (Sylvester 1994, Hartill et al. 1998) as methods were difficult to specify when the fishing operation was observed from a distance. Whether or not a boat was involved in the fishing operation was inadvertently omitted from the observer forms.

2.2 Interviews

Fishers were interviewed at specific sites on selected days. The aim was to interview all fishers from as many fishing parties as possible during an interview session, which typically lasted about 4 h. The Instructions to Interviewers and the interviewer recording forms are given in Appendix 3. These forms were based on the ones used in the North region and in the 1996 National Boat Ramp Surveys (Sylvester 1994, Hartill et al. 1998). A simplified list of possible fishing methods was used and included codes for whitebait fishing (not usually included). In accordance with the conventions adopted for marine recreational fishing surveys in New Zealand, fisher trips were defined by area fished, method used, and target species so any given fisher may make more than one "trip" during a fishing session.

Originally it was planned that interviews take place 1) at ramps, launch sites, or access points at the end of a fishing period, and 2) with beach fishers close to beach access points during their fishing

period. The low numbers of fishing parties that could be interviewed at the end of their fishing meant, however, that most fishers were interviewed during their fishing session.

Interviewers were identified by a cap and T-shirt carrying the logo of the Maketu Taiapure. The geography of the area, multiple accesses to fishing spots, and the mixed fishing activities possible meant that there were insufficient interview data to link interviews with particular observer sessions, so average data had to be used. Interviewers first determined that the fishing had taken place within the Taiapure. They then asked about the methods used, time fished, area fished, and numbers of each species caught, and they measured available fish. They also collected information on the experience of the fishers (either within or outside the Taiapure area).

We were aware that achieving a large enough sample size to achieve a reliable estimate of mean harvest rate, as estimated by Bradford & Francis (1999) and Bradford (2000), would be difficult. Interviews were mainly conducted at weekends and holidays (to maximise the number of fishers interviewed) and the interviewer went to one of the five ramps or interview routes defined. (A sample of the prescribed interview times and routes is given in Appendix 4.) The days when interviews were carried out at a particular site were randomly assigned.

Catches were identified (fish and shellfish references were supplied ensuring that all species were correctly named) and, when possible and appropriate, samples of the catch measured (using callipers for paua and rock lobster, measuring boards for fish).

The harvest rate for an individual species and trip was taken to be the number of fish caught divided by the time fished in hours (that is, fish per hour). This is formally a ratio estimator of harvest rate. Mean harvest rates were estimated using both the mean-of-ratios estimator (average of individual harvest rates) and the ratio-of-means estimator (mean harvest of all fishers divided by their mean fishing time). The variance of the mean-of-ratios estimator was calculated using the standard formula for variance of a random variable. The variance of the ratio-of-means estimator, for which there are several possible analytical expressions, was calculated by bootstrapping. Formal definitions of these estimators and expressions for their variance were given by Jones et al. (1995) and Bradford (2000) and are repeated in Appendix 5.

Jones et al. (1995) and Hoenig et al. (1997) suggested that the ratio-of-means estimator of mean harvest rate is the appropriate one to use when interviews are conducted at the end of a fishing trip, and the mean-of-ratios estimator is the appropriate one to use if interviews are conducted during a fishing trip. Hoenig et al. (1997) also suggested omitting trips that were less than half an hour long at the time of interview. These suggestions have been followed.

2.3 Data recording and entry

Copies of the forms used by the observers and interviewers are included in Appendix 6. The main recording forms had the map of the area (see Figure 1) on the back. The interview cover sheets were produced on coloured paper.

An Access database was designed for this survey based upon the *rec_data* Ministry of Fisheries database. This database had full online instructions and a comprehensive instruction manual was provided. To minimise data entry errors, allowed codes were defined for localities, fishing methods, and so on. The database contained separate tables for the observer and interview data.

2.4 Harvest estimates

Where possible, harvest estimates were made either by multiplying the estimated total fishing effort in hours by the harvest rate in fish per hour, or by multiplying the estimated total number of fishers by the mean harvest. The latter method was used for the shellfish harvest.

2.5 Auxiliary data

Daily summary weather data recorded at Tauranga and Whakatane Airports were obtained. Day length (sunrise to sunset) was calculated using a program that provided this information given a position (latitude and longitude) and date (Alistair Dunn, NIWA, Wellington, pers. comm.). Times of low tide were obtained from tide tables (New Zealand Nautical Almanac 2000, 2001) and from CASHCANZ (Coastal and shelf circulation around New Zealand, Derek Goring, NIWA, Christchurch, pers. comm.).

3. RESULTS AND DISCUSSION

3.1 Observer counts – general

The observed counts of fishers by locality (Table 2 and Figure 1) are shown in Figures 2–5. A problem arose with these counts in that data were not collected on all the days or times specified, and counts during the winter months were spasmodic. Fisher numbers were generally low, except in the Little Waihi Estuary.

At LP1, the late afternoon counts were made more frequently than those at the specified random times. For analysis, a "base case" set of observations was defined that contained the count at the random time, if it existed, and otherwise the late afternoon count, if it existed. Estimates of numbers of fishers were also made using the data from the random times and from the late afternoon counts. As a further sensitivity (for all lookout points), the specified observer sessions where there were no counts were assumed to have a zero count of fishers. The stratum mean of fishers by location was estimated for each case.

The first results presented are counts of the observer data: Table 3 gives the number of days in each stratum that were: available; specified as observer days; and on which observations were made.

Table 4 contains the numbers of fishers observed using one of the specified fishing methods by locality. The data are for 2000. Both random and late afternoon sessions from LP1 and sessions close to low tide in LP2 and LP3 are included. Table 5 is similar to Table 4 but contains the number of children (those thought to be younger than 15 but not including toddlers or younger) observed fishing. These data can be used to estimate the proportions of fishers using a particular method in a given locality. As might be expected, most fishers in the estuaries (ME1 and WE1) were hand gathering and elsewhere most of the fishers were using a line method. In the areas where both boat fishing and shore fishing could occur, the method "lines unspecified" may or may not have involved the use of a boat.

Table 6 gives the numbers of observer sessions where the specified environment conditions prevailed. Only the base case observations were used for LP1. Data for wind direction that was categorised into 10 levels were available but not given. Numbers of summer and winter sessions and the annual total are given. Good fishing conditions appeared to have prevailed on most observed days and the levels of environmental variables that were most likely to discourage fishing appeared to be more likely in winter.

Table 7 gives the mean number of fishers, averaged over the whole year, by locality and environmental state. Rough seas and rain appear to have been the environmental variables most likely

to discourage fishing (though remember that the numbers of observer sessions with adverse conditions were low).

It was impossible for the observers to tell whether non-commercial fishers were recreational fishers or fishers with a customary permit. As it seems likely that most fishers with customary permits fished on Thursdays or Fridays to be ready for weekend hui, the fisher counts on Thursdays may have included some customary fishers. It appears likely from discussions with Taiapure members that most fishers with customary permits were diving.

3.1.1 Detailed results

Observations from Okurei Point (LP1)

Most of the fishers observed from LP1 were using line methods (Table 4) and estimates of the numbers of fisher hours (effort) will be made assuming that all were using line methods. The numbers are such that only very rough estimates can be made of the fishing effort by method by apportioning the mean fisher numbers or estimated fishing total effort using the numbers in Table 4.

Table 8 contains the mean numbers of fishers observed by stratum and locality. The c.v. (coefficient of variation) of the mean fisher number is given and the fraction of observations where there were no fishers. Calculations were given for four cases: the base case using the observed values; the base case with all days specified as observer days but with no observations assumed to have no fishing (base case plus "no observations equals no fishing"); the observed sessions at random times; and the late afternoon observer sessions. In later calculations the last two cases also had a "no observations equals no fishing" variation. The mean fisher numbers were generally higher in summer and higher on weekends and holidays, as might be expected. However, mean fisher numbers on the Groyne (KR1) did not drop as much on weekdays and in winter as it did at the other localities. Weekday and winter fishing (all days) was unlikely in OP2, PB2, and PB1. There was little fishing on PB1, presumably due to the difficulties of access.

Mean fisher numbers were generally lower in the late afternoon than when observed at a random time during the day, except for KR1 and MB1 (around the Groyne) on summer weekends (Table 8). Numbers of fishers observed diving in OP1 and OP2 are discussed later in Section 3.3 because of the requirement to estimate the rock lobster (and paua) harvest. Few fishers were observed whitebaiting probably because these fishers would generally be hidden from the view of the observers.

To convert the mean fisher numbers (Table 8) into total fishing effort in hours requires knowledge of the number of hours in the day to which the mean number of fishers applies. We do not have an estimate of the mean fishing time for line methods from this survey as most interviews of fishers using line methods took place during their fishing trip (see the Methods section and the interview results later). We know from other surveys in the area that the mean fishing time for recreational fishers using line methods is 3–4 h (Bradford et al. 1998). A time of 3.5 hours was used as a minimal estimate of the number of hours that are fished during a day. However, fishers may be assumed to come and go throughout the day and as a maximal estimate, the length of the day between sunrise and sunset was used. For simplicity, and because of missing observations during winter, the mean day length over the summer and winter strata was used in the estimations (summer mean 13.17 hours; winter mean 11.36 hours). A modified day length (see Section 2.1) that mainly reduces the mean fishing day length in winter is also used (summer mean 13.07 hours; winter mean 9.78 hours). The stratum total, E_i, was estimated by multiplying the mean number of fishers, $\overline{F}_i$ (see Table 8), in a stratum by the assumed number of fishing hours in a day, e_i, and the number of days, d_i, in a stratum (see Table 3). The annual totals of fishing effort, E, were obtained by summing the stratum totals (Table 9).

It might be assumed that on weekends and holidays in summer the actual amount of fishing effort will be close to the maximal values, whereas on weekdays in winter the amount of fishing effort may be close to the minimal values. However, the true value of fishing effort over the year is likely to lie within the range of values given.

Thus, while we have fairly precise estimates of mean fisher numbers, the total amount of recreational fishing effort is known imprecisely (the values used are at best "guestimates") and the estimates given will all have unknown bias. Counts at the random times, especially from the Groyne, could be used to get an indication of the diurnal fisher numbers, at least in summer (missing observations in winter would lead to too many uncertainties). There would, however, be some confounding between time of day and time of year as fisher counts tend to drop off after the summer peak.

Observations of Little Waihi Estuary from LP3

Nearly all fishers observed in the Little Waihi Estuary were hand-gathering shellfish (see Table 4); from the interview data, they were primarily gathering pipi and appear to have had little difficulty in collecting what they perceived to be the daily limit. Hand gathering is carried out primarily around low tide when the shellfish become accessible. Some line fishing, diving, and set netting was observed and one fisher (probably an underestimate) was observed whitebaiting.

Table 10 contains the stratum average numbers of fishers (and c.v.) and the probability of no fishers being observed. Estimates were made for the observed sessions we have, and assuming "no observations means no fishing".

Table 11 contains estimates of the total fishing effort. For hand gathering, interviews were made at the end of a session and the mean time spent was 0.827 hours (about 50 minutes) in summer and 0.582 hours (about 35 minutes) in winter. This time was actually somewhat longer in summer and shorter in winter (see later). The total fishing effort was estimated assuming the above summer and winter fishing hours, and twice and five times these values.

Again, missing observer sessions, especially on weekdays and during winter, and the unknown number of "turnovers" of fishers mean that the estimates of total fishing effort are uncertain.

There was a rahui on Little Waihi Estuary for a few days after 20 March 2000 after a drowning and fishing activity would have been minimal for those days.

Observations of Maketu Estuary from LP2

Several fishing methods are used in the Maketu Estuary, as in Little Waihi, but handgathering was not as dominant (see Table 4). Observations were designed primarily to capture those people who were hand gathering (around low tide), but many of the fishers were surf-casting and this tends to be done at a different state of the tide. A rahui in place in this estuary during the first half of 2000 was intended to protect shellfish populations. The lifting of the rahui was not publicised widely but fisher numbers increased during the second half of the year as fishers realised that the rahui was gone (Figure 5).

Table 12 contains the mean fisher numbers by stratum. The rahui partially explains the high probability of no fishing being observed. The fishing effort was assumed to last for 4 h and 2 h in this estuary (Table 13).

3.2 Interview results

A total of 635 individual fisher interviews were made (some fishers would have been interviewed more than once but on different days). These included three (0.5%) who were fishing (diving) in the Taiapure with customary permits. (Most fishers holding a customary permit would fish on Thursday or Friday so that the catch was available for weekend hui. Since interviewing took place mainly at weekends, the interviewers were unlikely to intercept the customary fishers.) Fishers were asked how many days they had fished in the past year, not necessarily within the Taiapure area. The quartiles of the distribution of the replies are in Table 14: some fishers fished almost every day, suggesting there may be a core of regular and frequent fishers in the Taiapure.

In accordance with the conventions adopted for marine recreational fishing in New Zealand, fisher trips are defined by area fished, method used, and target species so a given fisher may make more than one "trip" during a fishing session. Tables 15 and 16 give the numbers of trips made by locality and by target species respectively.

More fishers were interviewed who had been whitebaiting near the Groyne (KR1) than had been observed (see Table 4). It is probable that people who were whitebaiting were not easily visible from the lookout point. Thus estimates of total whitebait harvest cannot be made.

Line fishers from the Groyne targeted kahawai or "fish". "Fish" equals an unspecified or multiple target species and can be assumed to include kahawai. Most fishers surfcasting on the beaches were targeting "fish". All fishers interviewed in the Little Waihi Estuary (WE1) were hand gathering and were targeting pipi. Very few fishers were interviewed from the Maketu Estuary (ME1).

Tables 17 and 18 contain the numbers of fish counted by fishing method and by locality. Kahawai is the only species where sufficient lengths were measured to estimate a reliable mean weight.

3.3 Harvest estimates

The project objective specifies that a methodology be established to estimate the recreational harvest of paua, rock lobster, and other species. There are considerable difficulties in making estimates of paua and rock lobster harvests due to the low numbers of fishers using methods suitable for harvesting these species.

Rock lobster

Pot activity was included in the fishing methods available for observers to use, but no records of this method were made during 2000. Potting was not one of the methods used by any fisher interviewed. We can conclude that few rock lobster were caught by recreational fishers using rock lobster pots in the area.

Most of the rock lobster caught by recreational fishers came from OP1 (37; Table 18), two came from OB1 (Otamarakau Beach), though two of the three fishers with customary permits had caught rock lobster in OP2. The proportions of fishers observed diving were small (13.6% in OP1, 10.9% in OP2, 0.7% in WE1, and otherwise 0). Table 19 shows how the fishers observed diving in OP1 and OP2 were distributed in the season/day type strata and the three "cases" used previously. Divers were mainly observed in summer and in the weekend. They were more likely to be seen at the random time than in the late afternoon. For the base case, the diver numbers were scaled to give stratum totals.

The interview data suggest that divers were targeting rock lobster, mussels, or "fish" and that they caught rock lobster and/or mussels and/or sea urchins. The mean harvest for rock lobster by recreational divers targeting or catching rock lobster (excluding those with customary permits) was three rock lobster. Divers seemed to take either the bag limit of six or take one or no lobsters. If the

estimated number of divers observed during one session per day, 185.5, caught three rock lobsters, the total harvest would be 556.5. However, this estimate has to be multiplied by the unknown "turnover rate" for divers. This suggests an annual harvest of rock lobster from the Maketu Taiapure of between 1000 and 2000. This number can be compared with the estimates of 223 000 in 1996 (Bradford 1998) and 306 000 in 2000 (preliminary, Boyd et al. 2001) from CRA 2 (boundaries near Leigh and East Cape).

Mussels

The mussel harvest is likely to be about 30 times the rock lobster harvest (using the ratio of the harvests counted in interviews in Table 18), that is between 30 000 and 60 000. Divers seem to have little trouble harvesting mussels up to the bag limit of 50. The three divers with customary permits harvested a total of 3500 mussels – they had all been fishing for 3–4 h. The 1996 diary survey estimate for the mussel harvest in QMA 1 (boundaries North Cape and Cape Runaway) was 818 000 (Bradford 1996).

Paua

No paua were encountered during the interviews, so, except that the paua harvest is probably small, no further estimate is possible.

Kahawai from the Groyne

The most clear cut sets of data that might be used to make estimates of total harvest are for the harvest of kahawai from fishers on the Groyne and of pipi from the Little Waihi Estuary. As noted above, the line fishers interviewed from this locality were either targeting kahawai or "fish".

Table 9 contains a range of estimates of the total number of hours fished in a year from the Groyne (KR1). These can be converted to harvest estimates by multiplying by the mean harvest rate in fish per hour obtained from the interview survey. Kahawai fishing trips are assumed to be those where kahawai or "fish" was given as the target species. Table 20(a) contains estimates of both the mean-of-ratios estimator, $\hat{H}_1$, and the ratio-of-means estimator, $\hat{H}_2$, of mean harvest rate for kahawai from the Groyne and from beaches in the Taiapure. Since most of these interviews were conducted during fishing the ratio-of-means estimator is the appropriate one to use (Jones et al. 1995). Table 20(b) contains an estimate of the mean weight of kahawai measured during the interview survey. Table 21 contains the estimates of the kahawai harvest from the Groyne using the 12 estimates of hours fished (in 100s) from Table 9 (the totals used included the fishers who were whitebaiting, but the bias introduced by this will be small relative to other potential biases. The annual kahawai harvest from the Groyne is estimated to lie between 16 and 59 t.

Other kahawai harvest

The kahawai harvest rate by surf-casting was about a fifth of the kahawai harvest rate from the Groyne (Table 20(a)). The interview data used came mainly from Otamarakau Beach (OB1) where we have no observer counts of fisher numbers. Few fishers were observed on Papamoa Beach and Pukehina Beach (PB1 and PB2). No attempt has been made to estimate the numbers of kahawai caught by surf-casting, but it is expected to be small in comparison with the kahawai harvest from the Groyne.

Yellow-eyed mullet from the Groyne

The yellow-eyed mullet harvest (in numbers) is likely to be about 30% of the kahawai harvest (in numbers) taken at the Groyne (using the ratio of counts from fisher interviews in Table 18), that is between 3000 and 10 000 fish. No estimate of tonnage is made; the actual mean weight of yellow-eyed mullet is unknown but would be about a fifth that of kahawai.

Pipi from Little Waihi Estuary

Table 22 contains a summary of the mean harvests and harvest rates of pipi from the interviews of fishers at the Little Waihi Estuary. The mean harvest is roughly constant seasonally and exceeds the daily bag limit for pipi of 150. It appears that the more expert fishers continue to harvest pipi throughout the year as the average trip length is considerably shorter in winter than summer. To estimate the total pipi extractions, the total number of handgathering fishers in a year was multiplied by 186.4 (the overall mean pipi harvest), 2 and 5 times this (a fisher turnover of 2 or 5), and as a minimal estimate, the daily bag limit (Table 23). It appears therefore that a few million pipi were taken from this estuary in 2000. The QMA 1 estimate for the pipi harvest in 1996 was 2 191 000 (Bradford 1998). (The estimates of pipi harvest from the national surveys are uncertain because only a few diarists recorded taking them and the individual harvests were often imprecise – half a bucket, say.)

Cockles from Little Waihi Estuary

The cockle harvest is likely to be about a tenth of the pipi harvest (using the ratio of counts from fisher interviews in Table 18).

Snapper

Table 24 is similar to Table 19 except that the fishers are those using line methods (excluding trolling) and possibly fishing from a boat (BA a baited line, and LU lines unspecified) in localities OP1 and OP2. It is assumed that all these fishers are fishing for snapper, either as a sole target or as part of mix of species. The scaled total number of these fishers is just under 750. It is then assumed that these fishers fished for 3.5 h and that there was a "turnover" factor of 2. That is, a total of 5250 h spent fishing for snapper.

Not enough snapper were counted during the interviews to make a reliable estimate of the mean snapper harvest rate. There are mean-of-ratios estimates of mean snapper harvest rate of 0.560 snapper per hour from around Motiti Island, 0.723 snapper per hour from the waters out from Papamoa Beach, and 1.069 snapper per hour from the waters out from Matata beach, but no estimate from the Pukehina Beach area (which includes most of the Taiapure area) from the 1996 boat ramp survey (Bradford 1999). The lack of information from the Pukehina Beach area in 1996 is a consequence of the location of interview sites in that survey. Snapper harvest rates are known to vary from year to year and possibly throughout the year. However, 0.75 snapper per hour could be reasonably considered the harvest rate of snapper within the Taiapure. The snapper harvest rate when surf casting from the beaches in the Taiapure appears to be small. Many of the people interviewed were targeting "fish" which probably included snapper and had caught nothing by the time of their interview.

Using these guestimates of hours spent fishing for snapper and the snapper harvest rate leads to a total harvest of snapper of about 4000 fish.

Blue maomao

Using the blue maomao to snapper harvest ratio from Table 18, perhaps the blue maomao harvest in OP1 and OP2 was 50% of the snapper harvest in those localities, or about 2000 fish.

Other species, other methods

Much the same sort of estimates as have been made for the rock lobster and snapper harvests could be made for other species and other fishing methods, but any confidence we might have about an estimate decreases as the numbers of fishers catching a species by a given method decreases. Tarakihi harvest appears to be much smaller than the snapper harvest (see Tables 17, 18).

3.4 Auxiliary data

The tidal information was used to determine the observation times in the estuaries. The climate data are of interest when deciding whether the days when observations were missed were likely to be non-fishing days.

Figures 6–8 show the daily maximum temperature, rainfall, and wind run at Tauranga and Whakatane Airports. The change in temperature during the year was considered when deciding upon the definition of the summer and winter strata. The maximum temperature was mainly above 20 °C during December to April inclusive, the summer strata, (Figure 6). Table 7 suggests that fishing becomes less likely as the rainfall becomes "medium scattered", though Table 6 suggests that such a condition was observed on only a few occasions.

In Figure 7, the line at 7.5 mm is included as a guide, when distinguishing days with no or light rainfall and moderate to heavy rainfall. April 2000 appears to have the greatest number of days with rainfall over 7.5 mm, but the winter of 2000 appears to have had several days on which rain might have deterred fishing.

Figure 8 suggests that the wind was most variable, that is a mixture of calm and very windy days, during June and July 2000. Strong winds also tend to deter fishing (see Table 7), especially when a boat is involved.

The climate data suggest that there will be some days, especially during winter, when fishers will have been deterred especially from taking a boat out to sea. A model of how climate affects fishing would be required to determine the actual number of non-fishable days. Such a model would probably use several weather records for each day; how fish behaviour is affected by the prevailing weather is another factor that would have to be considered – fish may become unavailable to the fishers under some conditions.

However, there is no conclusive evidence that all the days without observations would have been non-fishing days. Therefore, the mean fisher numbers calculated using the observed counts are likely to be more nearly correct than those estimated assuming no fishing on days specified for observations when observations were not made.

3.5. General discussion

The observed counts of fisher numbers give a detailed picture of recreational fishing patterns in the Maketu Taiapure. The interviews, which encountered very few (0.5%) fishers operating under customary permits, suggested almost all the fishing reported by the observers was indeed recreational fishing. The number of observer sessions was greater than would be required in the future but give useful information to feed into the design of a long-term survey. To use a reduced number of observer sessions, the observer days should be selected randomly within the time strata and observations should be done at a prescribed random time during the day (for observations not including the estuaries). Strict adherence to these days and times for observer sessions would be required to reduce bias that might occur due to non-random selection. Some days should be set aside for continuous observation so that the length of the fishing day and the "turnover rate" of fishers can be estimated.

The essential difficulty with producing harvest estimates arises from the difficulties in interviewing sufficient fishers to get good estimates of mean harvest and/or mean harvest rate. This was due in large part to the geographically extensive and disparate nature of the Taiapure area. The usual recreational harvest rate distributions (a high proportion of zero harvests and some very high individual harvest rates) need many observations to reliably define a mean harvest rate. In some cases, such as pipi from Little Waihi Estuary, where the daily limit or fisher requirements can be met easily, the estimation of reliable mean harvests and mean harvest rates has less stringent data requirements. For some important species, such as snapper and rock lobster, an adequate sampling routine is difficult to define – one almost has to have mandatory reporting of harvest. Fishers in some areas who might be defined as snapper fishers had a low harvest rate of any species. Rock lobster fishers seemed to divide into two classes – the hopefuls who caught zero or one animal and the experts who caught the daily limit.

As with all surveys, accurate recording and entry of the data are required. The way the seasonal strata were defined means that in future analyses of the recreational catch, the year from 1 December to 30 November would be a logical choice.

The second specific objective required the training of local volunteers in data analysis. Taiapure workers were shown how to assemble and extract data summaries from the Access database. They will have full access to this report, which shows how harvest estimates can be made given certain levels of observer and interview coverage.

Extension of the Maketu Taiapure to the 20 m contour is not expected to make much difference to the manner in which recreational data would be collected for this fishery, but inclusion of the offshore islands will probably necessitate ramp surveys at Mount Maunganui and Tauranga (and perhaps also Whakatane) since boats from these places fish these islands.

This has been the most intensive survey of a small area fishery in New Zealand to date, especially with respect to the observation of fishing effort. (Reports of results from other surveys are not generally available as they are all contained in reports to the Ministry of Fisheries). Volunteers carried out the data collection and without their work no estimates of fishing patterns in, and harvest from, the Maketu Taiapure, would have been possible.

4. CONCLUSIONS

Intensive effort is required to obtain reliable (that is, with known error) harvest estimates in small, diverse, multi-access, multi-species, multi-method fisheries. If, as for the Maketu Taiapure, the components of the fishery can be observed from a small number of lookout points, then counts of fishers can easily be made (given that observers are available). Now that we have a good idea of the variation of fishing intensity throughout the year, the number of observer sessions could be reduced, but they would need to be done on randomly selected days at randomly selected times. One observation, critical to making harvest estimates, is the variation of fisher numbers by locality by time stratum. Adequate observations of this type were not included in the design of this survey during 2000.

Ideally, interview sessions should have been more frequent particularly in the areas where divers and boat fishers were likely to be intercepted.

It is not clear that the methods used in this survey would be suitable for use in other taiapure and similar areas. The methods are very labour intensive and their implementation requires a very good organiser of voluntary labour and someone with an understanding of the importance of random observations for achieving unbiased estimates of harvest.

This survey was directed at estimating recreational fishing harvests within the Maketu Taiapure. Another important non-commercial harvest is that taken by fishers with customary permits and this harvest would need to be taken into account if any taiapure specific fishing regulations are introduced.

In future surveys, it seems to us to be most sensible to limit the estimates of harvest or other quantities to sedentary species, such as shellfish, where local controls can affect the local stocks. Although the kahawai harvest from the Groyne is quite high, the number of fishers who can fish there is limited by space and limiting the kahawai harvest below the regional daily limit would have little overall effect on the highly mobile kahawai stock. Simple methods for estimating abundance changes of pipi and cockles in the estuaries and perhaps on nearby beaches, and the abundance of mussels, paua, and kina on the reefs off Okurei Point, are required for the Maketu Taiapure. Such methods might involve designed surveys, or at the simplest level, rely on local information on declining harvest rates. If the stock appeared to be declining a rahui could be imposed. This would give an effective method of allowing stocks to regenerate, providing the rahui is enforceable.

Some means of continuing payment for the local organisers seems desirable.

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Table 1: Common and scientific names of species counted during the interview sessions or mentioned in this report.

Common name	Scientific name
Blue maomao	*Scorpis violaceus*
Bronze whaler shark	*Carcharhinus brachyurus*
Freshwater eel	Family Anguillidae
Red gurnard	*Chelidonichthys kumu*
Hammerhead shark	*Sphyrna zygaena*
Kahawai	*Arripis trutta*
Kingfish	*Seriola lalandi lalandi*
Snapper	*Pagrus auratus*
Tarakihi	*Nemadactylus macropterus*
Trevally	*Pseudocaranx dentex*
Yellow-eyed mullet	*Aldrichetta forsteri*
Whitebait	Family Galaxiidae (juvenile)
Rock lobster	Assumed *Jasus edwardsii*
Cockles	*Austrovenus stutchburyi*
Mussels	*Perna canaliculus*
Oysters	Probably *Crassostrea gigas*
Pipi	*Paphies australis*
Paua	Assumed *Haliotis iris*
Sea urchins	*Evechinus chloroticus*

Table 2: Fishing area codes (see Figure 1).

PB1	Papamoa Beach to Kaituna Cut
KR1	Kaituna River
MB1	Maketu Estuary Beach
ME1	Maketu Estuary
OP1	West of line from Okurei Point to Motunau Is and out to 3 km
OP2	East of line from Okurei Point to Motunau Is and out to 3 km
WE1	Little Waihi Estuary
PB2	Pukehina Beach
OB1	Otamarakau Beach

Table 3: Number of days per stratum for 2000 (summer is January-April plus December). The last 5 lines give the numbers of days in the stratum when observations were made. See text for further detail.

	Summer		Winter		Total
	Weekend	Weekday	Weekend	Weekday	
Total days in stratum	60	92	62	152	366
Sessions specified	58	37	62	64	221
Sessions observed					
LP1, base case	57	36	45	54	192
LP1, random	41	22	30	29	122
LP1, afternoon	51	33	41	50	175
LP2, low tide	42	20	48	44	154
LP3, low tide	42	23	33	25	123

Table 4: Numbers of fishers observed by fishing method and locality during 2000. Random and late afternoon observations from LP1 are used and low tide observations from LP2 and LP3. Locality codes are defined in Table 2.

Method	KR1	MB1	OP1	OP2	PB1	PB2	ME1	WE1	ALL
Baited line; boat	0	14	307	152	0	0	6	0	479
Trolling	0	5	7	2	1	0	0	0	15
Lines; unspecified	1	31	173	95	23	17	6	17	363
Line fishing; shore	499	939	94	197	81	254	113	86	2 263
Lines from Groyne	1 532	19	0	0	0	0	0	0	1 551
Hand gathering	0	102	79	45	0	0	424	3 109	3 759
Diving	0	0	105	60	0	0	0	22	187
Drag net	0	0	0	0	0	0	17	0	17
Set net	0	3	0	0	0	0	5	23	31
Net activity	0	0	0	0	0	0	4	6	10
White bait	9	0	0	0	0	0	0	1	10
Other	0	0	1	0	0	0	0	3	4
Unidentified	0	0	4	1	1	0	1	0	7
Total	2 041	1 113	770	552	106	271	576	3 267	8 696

Table 5: As for Table 4, but just giving numbers of children (under 15 but not including toddlers).

	KR1	MB1	OP1	OP2	PB1	PB2	ME1	WE1	ALL
Baited line; boat	0	0	0	2	0	0	6	0	8
Lines; unspecified	0	0	0	0	0	0	5	0	5
Line fishing; shore	20	1	0	1	0	14	38	4	78
Hand gathering	0	5	7	1	0	0	112	262	387
Set net	0	0	0	0	0	0	0	2	2
Total	20	6	7	4	0	14	161	268	480

Table 6: Number of observer sessions during 2000 when the environmental conditions were recorded as the categories listed. Sum., summer (January-April plus December); Win., winter. See text for further detail.

	LP1 base case			LP2			LP3		
	Sum.	Win.	All	Sum.	Win.	All	Sum.	Win.	All
Total	93	99	192	62	92	154	65	58	123
Sea state									
Smooth (0.1–0.5 m)	52	47	99	10	38	48	62	45	107
Slight (0.5–1.0 m)	32	31	63	39	30	69	1	3	4
Moderate (1.0–2.5 m)	9	15	24	12	16	28	2	8	10
Rough (2.5–4.0 m)	0	6	6	1	8	9	0	2	2
Rain									
Nil	85	84	169	37	62	99	62	46	108
Light continuous	2	5	7	14	9	23	2	8	10
Light scattered	3	3	6	9	13	22	0	2	2
Medium scattered	3	7	10	2	8	10	1	2	3
Overhead									
Sunny continuous	39	33	72	10	21	31	26	16	42
Mainly sunny	15	19	34	31	21	52	8	12	20
Mainly cloudy	18	16	34	19	30	49	18	15	33
Continuous cloud	21	31	52	2	20	22	13	15	28
Wind strength									
Nil	21	28	49	6	13	19	26	9	35
Light (1–10 kts)	49	40	89	35	48	83	29	25	54
Medium (10–21 kts)	18	24	42	21	23	44	9	19	28
Strong (21+ kts)	5	7	12	0	8	8	1	5	6

Table 7: Mean fisher numbers throughout the year by locality and environmental state. The localities observed from LP1 use the base case observations. The locality codes are defined in Table 2.

	KR1	MB1	OP1	OP2	PB1	PB2	ME1	WE1
Total	6.9	3.6	2.9	2.1	0.5	0.8	3.7	26.4
Sea state								
Smooth (0.1-0.5 m)	7.7	4.6	4.0	2.7	0.6	1.1	4.1	28.0
Slight (0.5-1.0 m)	7.4	2.8	2.2	1.9	0.4	0.5	4.3	17.5
Moderate (1.0-2.5 m)	4.0	1.8	0.7	0.6	0.0	0.6	1.8	14.8
Rough (2.5-4.0 m)	0.3	0.0	0.0	0.0	0.0	0.0	1.9	18.5
Rain								
Nil	7.5	3.9	3.2	2.3	0.5	0.9	4.8	27.3
Light continuous	4.0	1.1	0.1	0.3	0.0	0.0	1.8	24.3
Light scattered	4.3	1.7	1.5	3.0	0.0	0.5	1.5	16.0
Medium scattered	0.3	0.0	0.0	0.0	0.0	0.0	1.8	8.7
Overhead								
Sunny continuous	7.9	4.8	4.2	3.1	0.8	1.0	4.8	29.4
Mainly sunny	7.5	3.7	2.7	1.2	0.4	0.9	5.2	23.3
Mainly cloudy	7.7	3.9	2.7	1.9	0.3	1.0	2.4	32.9
Continuous cloud	4.6	1.5	1.3	1.5	0.1	0.4	1.2	16.5
Wind strength								
Nil	7.3	3.0	3.2	2.9	1.0	0.7	3.5	21.6
Light (1-10 kts)	7.0	4.4	3.4	2.0	0.2	1.1	4.1	31.5
Medium (10-21 kts)	6.9	2.4	2.0	1.7	0.5	0.5	3.5	26.4
Strong (21+ kts)	4.6	3.3	0.4	1.2	0.0	0.7	1.0	8.8

Table 8: Mean number of fishers, $\overline{F}$ and c.v. (coefficient of variation), seen from LP1 by strata in 2000 (summer is January-April plus December). p_0 is the proportion of observations when no fishers were seen. Results are given for the base case, the base case with zeros added on the missing observation days, the observations at a random time, and the late afternoon observations (see text). The locality codes are defined in Table 2. –, unavailable.

	Base case			Base case with added zeros			Random time			Late afternoon		
	$\overline{F}$	c.v.	p_0	$\overline{F}$	c.v.	p_0	$\overline{F}$	c.v.	p_0	$\overline{F}$	c.v.	p_0
KR1												
Summer weekend	9.2	6.6	0.02	9.0	6.8	0.03	8.3	8.5	0.02	9.1	7.8	0.04
Summer weekday	5.5	11.7	0.08	5.3	12.1	0.11	6.5	14.2	0.05	6.2	14.3	0.09
Winter weekend	6.9	12.0	0.18	5.0	14.4	0.40	6.8	13.0	0.13	6.0	14.1	0.24
Winter weekday	5.5	11.7	0.17	4.6	12.9	0.30	5.9	15.4	0.10	5.4	12.2	0.18
MB1												
Summer weekend	6.5	10.8	0.12	6.4	10.9	0.14	6.0	14.5	0.15	8.1	11.2	0.04
Summer weekday	2.0	21.6	0.44	2.0	21.8	0.46	1.9	25.2	0.45	1.8	24.4	0.45
Winter weekend	3.0	22.3	0.44	2.2	23.6	0.60	3.4	27.4	0.43	2.6	20.1	0.41
Winter weekday	1.9	28.4	0.57	1.6	28.9	0.64	1.5	27.0	0.52	2.0	28.7	0.56
OP1												
Summer weekend	5.1	16.5	0.35	5.0	16.6	0.36	5.8	18.9	0.29	3.4	20.1	0.45
Summer weekday	1.7	22.6	0.50	1.7	22.7	0.51	1.9	28.7	0.50	1.7	21.1	0.42
Winter weekend	3.1	26.2	0.58	2.2	27.2	0.69	3.8	30.0	0.53	1.9	28.2	0.66
Winter weekday	1.1	24.1	0.67	0.9	24.6	0.72	1.3	32.6	0.69	0.7	27.1	0.72
OP2												
Summer weekend	5.4	14.5	0.30	5.3	14.6	0.31	6.1	15.9	0.24	3.6	16.0	0.37
Summer weekday	1.4	27.5	0.61	1.4	27.6	0.62	1.5	34.4	0.55	0.7	37.1	0.73
Winter weekend	0.9	51.1	0.89	0.7	51.4	0.92	1.2	58.4	0.87	0.3	66.0	0.93
Winter weekday	0.1	57.2	0.94	0.1	57.3	0.95	0.1	101.8	0.97	0.1	46.1	0.90
PB1												
Summer weekend	0.2	70.7	0.96	0.2	70.7	0.97	0.3	70.7	0.95	0.1	74.7	0.96
Summer weekday	0.0	–	1.00	0.0	–	1.00	0.0	–	1.00	0.0	–	1.00
Winter weekend	1.0	37.0	0.78	0.7	37.6	0.84	1.3	38.8	0.73	0.3	40.5	0.85
Winter weekday	0.6	29.4	0.76	0.5	29.8	0.80	0.6	47.2	0.83	0.4	31.6	0.78
PB2												
Summer weekend	2.2	14.1	0.37	2.2	14.2	0.38	2.3	16.7	0.37	2.3	20.2	0.45
Summer weekday	0.8	30.2	0.67	0.7	30.3	0.68	1.0	35.0	0.64	0.7	34.9	0.70
Winter weekend	0.1	82.9	0.96	0.1	82.8	0.97	0.2	83.2	0.93	0.2	63.3	0.93
Winter weekday	0.0	–	1.00	0.0	–	1.00	0.0	–	1.00	0.0	–	1.00

Table 9: Estimates of fisher hours (100s) in 2000 (summer is January-April plus December). Four estimates are made for each of the base case, the random observations, and the late afternoon observations. These are: A, using the observations of fisher numbers available and mean day length in the strata as the available fishing time; B, as for A but using the modified mean day length (less fishing time in winter); C, as for A but using a mean fishing day length of 3.5 hours; and D, as for A, but with the assumption that there was no fishing on the days specified for observations when there were no observations. The locality codes are defined in Table 2.

	Base case				Random time				Late afternoon			
	A	B	C	D	A	B	C	D	A	B	C	D
KR1												
Summer weekend	73	72	19	71	66	65	17	47	72	71	19	63
Summer weekday	67	66	18	64	79	78	21	47	75	75	20	67
Winter weekend	49	42	15	35	48	41	15	23	42	36	13	28
Winter weekday	95	82	29	79	102	88	31	47	93	80	29	73
Total	284	262	81	249	295	272	84	164	282	262	81	231
MB1												
Summer weekend	51	51	14	51	47	47	13	33	64	64	17	56
Summer weekday	24	24	6	24	23	23	6	13	22	22	6	19
Winter weekend	21	18	7	15	24	21	7	12	18	16	6	12
Winter weekday	33	28	10	28	26	22	8	12	35	30	11	28
Total	129	121	37	118	120	113	34	70	139	132	40	115
OP1												
Summer weekend	40	40	11	40	46	45	12	32	27	27	7	23
Summer weekday	21	20	5	21	23	23	6	13	21	20	5	18
Winter weekend	22	19	7	15	27	23	8	13	13	12	4	9
Winter weekday	19	16	6	16	22	19	7	10	12	10	4	9
Total	102	95	29	92	118	110	33	68	73	69	20	59
OP2												
Summer weekend	43	42	11	42	48	48	13	34	28	28	8	25
Summer weekday	17	17	5	17	18	18	5	11	8	8	2	7
Winter weekend	6	5	2	5	8	7	3	4	2	2	1	1
Winter weekday	2	1	1	2	2	1	1	0	2	1	1	2
Total	68	65	19	66	76	74	22	49	40	39	12	35
PB1												
Summer weekend	2	2	0	2	2	2	1	2	1	1	0	1
Summer weekday	0	0	0	0	0	0	0	0	0	0	0	0
Winter weekend	7	6	2	5	9	8	8	4	2	2	1	1
Winter weekday	10	9	3	9	10	9	9	5	7	6	2	5
Total	19	17	5	16	21	19	19	11	10	9	3	7
PB2												
Summer weekend	17	17	5	17	18	18	5	13	18	18	5	17
Summer weekday	10	10	3	8	12	12	3	7	8	8	2	7
Winter weekend	1	1	0	1	1	1	0	1	1	1	0	1
Winter weekday	0	0	0	0	0	0	0	0	0	0	0	0
Total	28	28	8	26	31	31	8	21	27	27	7	25

Table 10: Mean number of fishers, $\overline{F}$ and c.v. (coefficient of variation) in the Little Waihi Estuary, seen from LP3 by strata in 2000 (summer is January-April plus December). p_0 is the proportion of observations when no fishers were seen. Results are given using the observations, and the observations augmented by zeros for the specified observer days when no observations were made.

	Observed			Observed with added zeros		
	$\overline{F}$	c.v.	p_0	$\overline{F}$	c.v.	p_0
Summer weekend	48.7	11.4	0.00	35.3	14.0	0.28
Summer weekday	16.2	15.5	0.04	10.1	20.1	0.41
Winter weekend	18.3	13.5	0.15	9.7	18.0	0.55
Winter weekday	9.0	18.1	0.08	3.5	23.7	0.64

Table 11: Estimated number of fisher hours (100s) in Little Waihi Estuary in 2000 (summer is January-April plus December). Results are given for the observations and the observations augmented by zeros. A, assumes a mean fishing time of 0.827 h in summer and 0.582 h in winter (the mean fishing times for hand gatherers in the interviews); B, twice this; C, five times this. Note 1, 2, and 5 are the assumed "turnover" factors for fishers.

	Observed			Observed with added zeros		
	A	B	C	A	B	C
Summer weekend	24	48	121	18	35	88
Summer weekday	12	25	62	8	15	38
Winter weekend	7	13	33	4	7	18
Winter weekday	8	16	40	3	6	15
Total	51	102	256	33	63	159

Table 12: Mean number of fishers, $\overline{F}$ and c.v. (coefficient of variation) in the Maketu Estuary, seen from LP2 by strata in 2000 (summer is January-April plus December). p_0 is the proportion of observations when no fishers were seen. Results are given using the observations, and the observations augmented by zeros for the specified observer days when no observations were made. Note: there was a rahui in place for the Maketu Estuary during the first half of 2000.

	Observed			Observed with added zeros		
	$\overline{F}$	c.v.	p_0	$\overline{F}$	c.v.	p_0
Summer weekend	2.3	20.0	0.50	1.7	21.5	0.64
Summer weekday	1.2	39.0	0.70	0.6	41.1	0.84
Winter weekend	2.8	26.7	0.63	2.1	27.5	0.71
Winter weekday	0.6	37.7	0.80	0.4	38.4	0.86

Table 13: Estimated number of fisher hours (100s) in Maketu Estuary in 2000 (summer is January-April plus December). Results are given for the observations and the observations augmented by zeros. A, assumes a mean fishing time of 4 h (the mean fishing time for hand gatherers in the interviews); B, half this.

	Observed		With zeros	
	A	B	A	B
Summer weekend	6	3	4	2
Summer weekday	4	2	2	1
Winter weekend	7	3	5	3
Winter weekday	4	2	2	1
Total	21	10	13	7

Table 14: Fisher experience in 2000. Statistics of the number of days fished (anywhere) by fishers interviewed by locality. *N*, number of fishers interviewed; Qu., quartile. Locality codes are defined in Table 2.

	KR1	MB1	OP1	OP2	PB2	OB1	ME1	WE1	ALL
N	154	30	24	41	40	164	5	177	635
Min.	1	1	3	1	5	1	12	0	0
1st Qu.	10	11	25	6	24	12	24	4	10
Median	22	25	50	20	50	25	24	12	20
Mean	38	31	55	29	76	45	22	31	40
3rd Qu.	50	50	60	40	128	50	24	30	50
Max.	300	150	300	130	200	250	24	300	300

Table 15: Fishing method used by locality on fisher trips during 2000. Locality codes are defined in Table 2. Three fishers who were diving under customary permits have been omitted.

Method	Code	KR1	MB1	OP1	OP2	PB2	OB1	ME1	WE1	ALL
Baited line; boat	BA	0	0	12	9	0	2	0	0	23
Line fishing; shore	RS	5	30	4	12	38	159	0	0	248
Kontiki	KO	0	0	0	0	2	6	0	0	8
Lines from Groyne	WH	127	0	0	0	0	0	0	0	127
Hand gathering	HA	0	0	0	8	0	0	5	177	190
Diving	DI	0	0	10	10	0	0	0	0	23
Whitebait; scoop	WB	14	0	0	0	0	0	0	0	14
Whitebait; static	WS	8	0	0	0	0	0	0	0	8
Total		154	30	26	39	40	167	5	177	638

Table 16: Target species given by locality on fisher trips during 2000. Locality codes are defined in Table 2. Three fishers who were diving under customary permits have been omitted.

Target species	KR1	MB1	OB1	OP1	OP2	PB2	WE1	ME1	ALL
Kahawai	113	1	0	0	0	0	0	0	114
Snapper	0	0	7	3	2	2	0	0	14
Tarakihi	0	0	0	2	0	0	0	0	2
"Fish"	19	29	157	7	21	38	0	0	271
Rock lobster	0	0	3	10	0	0	0	0	16
Mussels	0	0	0	3	15	0	0	0	18
Pipi	0	0	0	0	0	0	177	4	181
Sea urchins	0	0	0	1	1	0	0	0	2
Eels	0	0	0	0	0	0	0	1	1
Whitebait	22	0	0	0	0	0	0	0	22

Table 17: Numbers of fish and shellfish counted by method type during 2000. The method codes are given in Table 15. Catch of three fishers who were diving under customary permits have been omitted, but the measured rock lobster include 19 fish caught by these fishers.

	BA	RS	KO	WH	HA	DI	WB	WS	Total	Measured
Blue maomao	30	0	0	0	0	0	0	0	30	9
Bronze whaler shark	1	0	0	0	0	0	0	0	1	1
Fresh water eel	0	0	0	0	1	0	0	0	1	1
Red gurnard	7	11	1	0	0	0	0	0	19	19
Hammerhead shark	1	0	0	0	0	0	0	0	1	1
Kahawai	2	92	3	328	0	0	0	0	425	384
Kingfish	2	0	0	0	0	0	0	0	2	0
Snapper	61	41	7	0	0	0	0	0	109	83
Tarakihi	17	0	0	0	0	0	0	0	17	15
Trevally	2	1	0	0	0	0	0	0	3	3
Yellow-eyed mullet	0	2	0	122	0	0	0	0	124	0
Unidentified	0	9	0	0	0	0	0	0	9	0
Whitebait	0	0	0	0	0	0	3 100	1 720	4 820	0
Rock lobster	0	0	0	0	0	39	0	0	39	57
Cockles	0	0	0	0	3 500	0	0	0	3 500	0
Mussels	0	0	0	0	406	690	0	0	1 096	0
Oysters	0	0	0	0	140	0	0	0	140	0
Pipi	0	0	0	0	33 000	0	0	0	33 000	0
Sea urchins	0	0	0	0	20	181	0	0	201	0
	123	156	11	450	37 067	910	3 100	1 720	43 537	

Table 18: Number of fish and shellfish counted by locality during 2000. Locality codes are defined in Table 2. Catch of three fishers who were diving under customary permits have been omitted.

	KR1	MB1	OP1	OP2	PB2	OB1	ME1	WE1	ALL
Blue maomao	0	0	23	7	0	0	0	0	30
Bronze whaler shark	0	0	0	0	0	1	0	0	1
Fresh water eel	0	0	0	0	0	0	1	0	1
Red gurnard	0	0	7	0	2	10	0	0	19
Hammerhead shark	0	0	1	0	0	0	0	0	1
Kahawai	328	43	2	1	2	49	0	0	425
Kingfish	0	0	0	2	0	0	0	0	2
Snapper	0	1	46	15	12	35	0	0	109
Tarakihi	0	0	17	0	0	0	0	0	17
Trevally	0	0	2	0	0	1	0	0	3
Yellow-eyed mullet	122	0	0	1	0	1	0	0	124
Unidentified	0	9	0	0	0	0	0	0	9
Whitebait	4 820	0	0	0	0	0	0	0	4 820
Rock lobster	0	0	37	0	0	2	0	0	39
Cockles	0	0	0	0	0	0	200	3 300	3 500
Mussels	0	0	430	666	0	0	0	0	1 096
Oysters	0	0	0	0	0	0	0	140	140
Pipi	0	0	0	0	0	0	200	32 800	33 000
Sea urchins	0	0	100	101	0	0	0	0	201
	5 270	53	665	793	16	99	401	36 240	43 537

Table 19: Numbers of divers observed diving from LP1 during 2000 by strata and the cases used in the previous analysis. The number of observer sessions by strata and case are repeated from Table 3. The base case is a composite of the random observations and some late afternoon observations. The scaled diver numbers multiply the average number of divers observed in a session by the number of days in the stratum. Summer is January-April plus December. Locality codes are defined in Table 2.

		Summer		Winter		
Locality	Case	Weekend	Weekday	Weekend	Weekday	Total
Diver counts						
OP1	Base	62	14	5	5	86
	Random	49	4	5	5	63
	Late afternoon	21	20	0	1	42
OP2	Base	38	8	0	0	46
	Random	37	2	0	0	39
	Late afternoon	12	6	2	1	21
Session counts						
LP1	Base	57	36	45	54	
	Random	41	22	30	29	
	Late afternoon	51	33	41	50	
Days in stratum		60	92	62	152	
Scaled diver numbers						
OP1	Base	65.3	35.8	6.9	14.1	122.1
OP2		40.0	20.4	0	3.0	63.4

Table 20: (a) Kahawai harvest rates during 2000. N, number of fishers; $\hat{H}_1$, mean-of-ratios harvest rate estimate; $\hat{H}_2$ ratio-of-means harvest rate estimator; c.v., coefficient of variation. Fishing times less than or equal to 0.5 h are ignored.

	N	$\hat{H}_1$	c.v.	$\hat{H}_2$	c.v.
All methods on and around Groyne	118	1.201	12.2	1.010	11.9
From beaches, including kontiki	175	0.257	20.5	0.260	24.3

20: (b) Kahawai measured length statistics (cm) and mean weight (kg) with c.v.s (coefficient of variation) for mean values. N is the number of fish measured. The mean weight is estimated using aL^b where L is the length in cm, a=10^{-5} and b=3.14 (Drummond 1994).

N	Min.	Max.	Median	Mean	c.v.	Mean wt	c.v.
384	22	69	45.5	44.32	1.0	1.655	2.8

Table 21: Estimated kahawai harvest from the Groyne during 2000. Estimates of fishing hours are taken from Table 9. Four estimates are made for each of the base case, the random observations, and the late afternoon observations. These are: A, using the observations of fisher numbers available and mean day length in the strata as the available fishing time; B, as for A but using the modified mean day length (less fishing time in winter); C, as for A but using a mean fishing day length of 3.5 hours; and D, as for A, but with the assumption that there was no fishing on the days specified for observations when there were no observations. The kahawai catch rate was assumed to be 1.2 fish/h and the mean weight 1.655 kg.

		Hours (100s)	Kahawai (100s)	Kahawai harvest (t)
Base case				
	A	284	341	56.40
	B	262	314	52.03
	C	81	97	16.06
	D	249	299	49.45
Random				
	A	295	354	58.59
	B	272	326	54.02
	C	84	101	16.68
	D	164	197	32.57
Late afternoon				
	A	282	338	56.01
	B	262	314	52.03
	C	81	97	16.09
	D	231	277	45.88

Table 22: Pipi harvest rates during 2000 (summer is January-April plus December). N, number of fishers; $\overline{C}$, mean harvest; $\overline{T}$, mean fishing time; $\hat{H}_1$, mean-of-ratios harvest rate estimate; $\hat{H}_2$, ratio-of-means harvest rate estimate and c.v.s (coefficient of variation).

Period	N	$\overline{C}$	c.v.	$\overline{T}$ (mins)	c.v.	$\hat{H}_1$	c.v.	$\hat{H}_2$	c.v.
Summer	69	184.1	7.1	49.6	9.3	321.2	8.5	222.7	12.6
Winter	107	187.9	6.0	34.9	4.2	391.4	7.1	323.2	7.3
All year	176	186.4	4.6	40.7	5.1	363.9	5.5	275.1	7.0

Table 23: Numbers of pipi harvested (1000s) in Little Waihi Estuary during 2000 (summer is January-April plus December). Results are given for the observations and the observations augmented by zeros. A, assumes a mean harvest of 186.4; B, twice this; C, five times this; and D is like A but assumes that the mean pipi harvest equals the bag limit of 150.

	Observations				*Observations with added zeros*			
	A	B	C	D	A	B	C	D
Summer weekend	522	1 045	2611	420	378	756	1890	304
Summer weekday	262	525	1312	211	163	326	815	131
Winter weekend	199	398	994	160	106	213	532	86
Winter weekday	241	482	1204	194	93	187	467	75
Total	1 224	2 450	6 121	985	740	1 482	3 704	596

Table 24: Numbers of fishers observed during 2000 using lines (excluding trolling) in OP1 and OP2 by strata and the cases used in the previous analysis. Locality codes are defined in Table 2. The number of observer sessions by strata and case are repeated from Table 3. The base case is a composite of the random observations and some late afternoon observations. The scaled diver numbers multiply the average number of divers observed in a session by the number of days in the stratum. Summer is January-April plus December.

		Summer		Winter		
Locality	Case	Weekend	Weekday	Weekend	Weekday	Total
Fisher counts						
OP1	Base	210	40	85	15	350
	Random	179	31	74	13	297
	Late afternoon	124	23	34	2	183
OP2	Base	150	16	33	6	205
	Random	130	14	31	2	177
	Late afternoon	60	4	2	4	70
Session counts						
LP1	Base	57	36	45	54	
	Random	41	22	30	29	
	Late afternoon	51	33	41	50	
Days in stratum		60	92	62	152	
Scaled fisher numbers						
OP1	Base	221.1	102.2	117.1	42.2	482.6
OP2		157.9	40.9	45.5	16.9	261.2

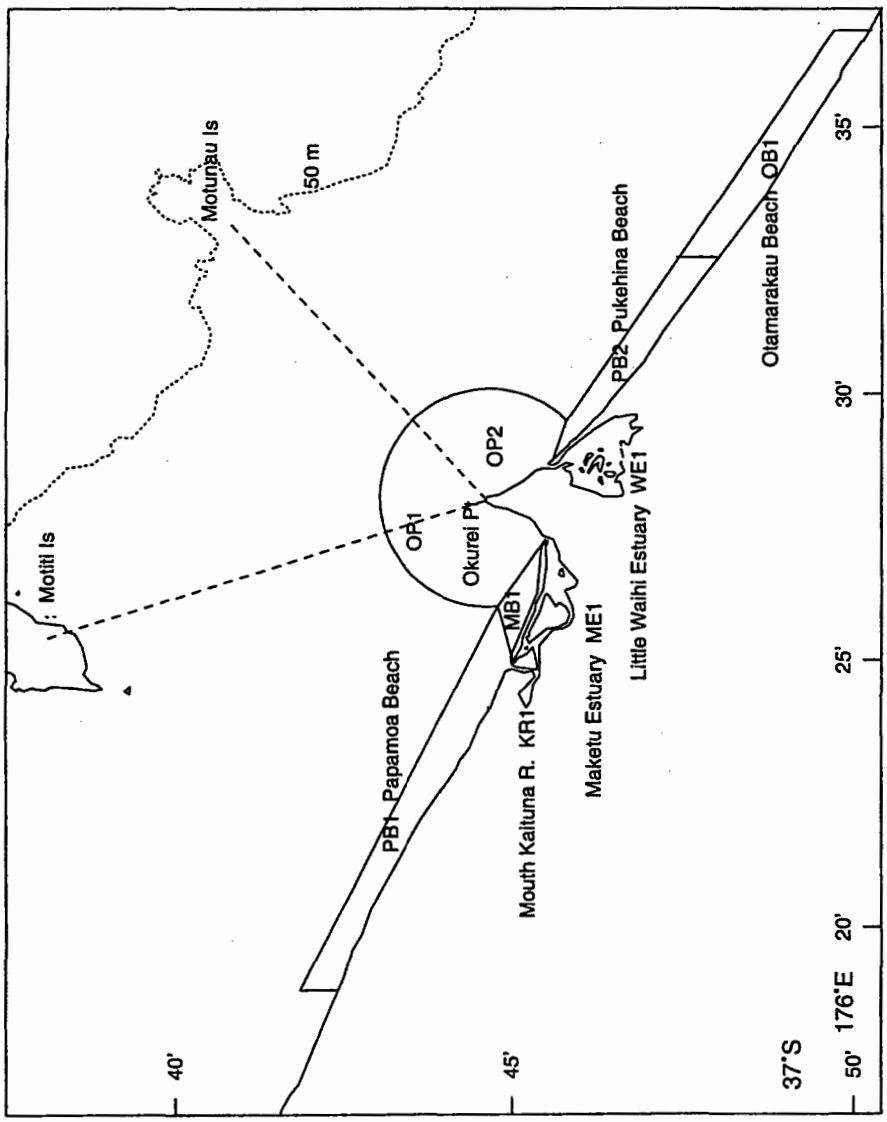

Figure 1: Map of the Maketu Taiapure area indicating the fishing locations defined (see Table 2) for this survey. The townships of Papamoa Beach, Pukehina, and Otamarakau are close to the beaches that bear their name and tend to extend linearly along much of the beach. MB1 is Maketu Beach, the sea side of the spit forming one side of the Maketu Estuary.

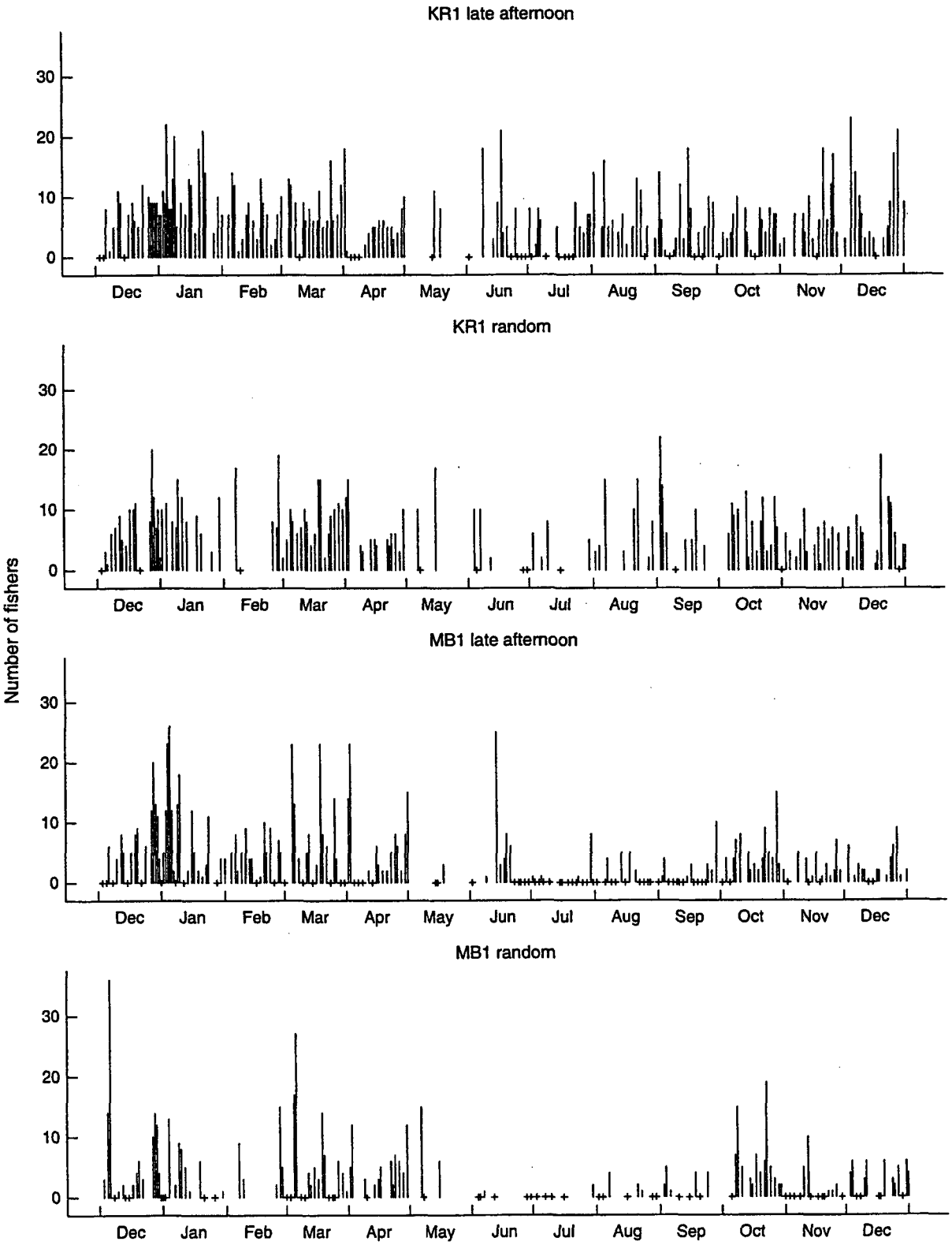

Figure 2: Numbers of fishers seen from LP1 (see Figure 1) at the random and late afternoon observing times at the fishing localities KR1 and MB1 (the Groyne at the mouth of the Kaituna River and the nearby beach), December 1999–December 2000. +, no fishers seen.

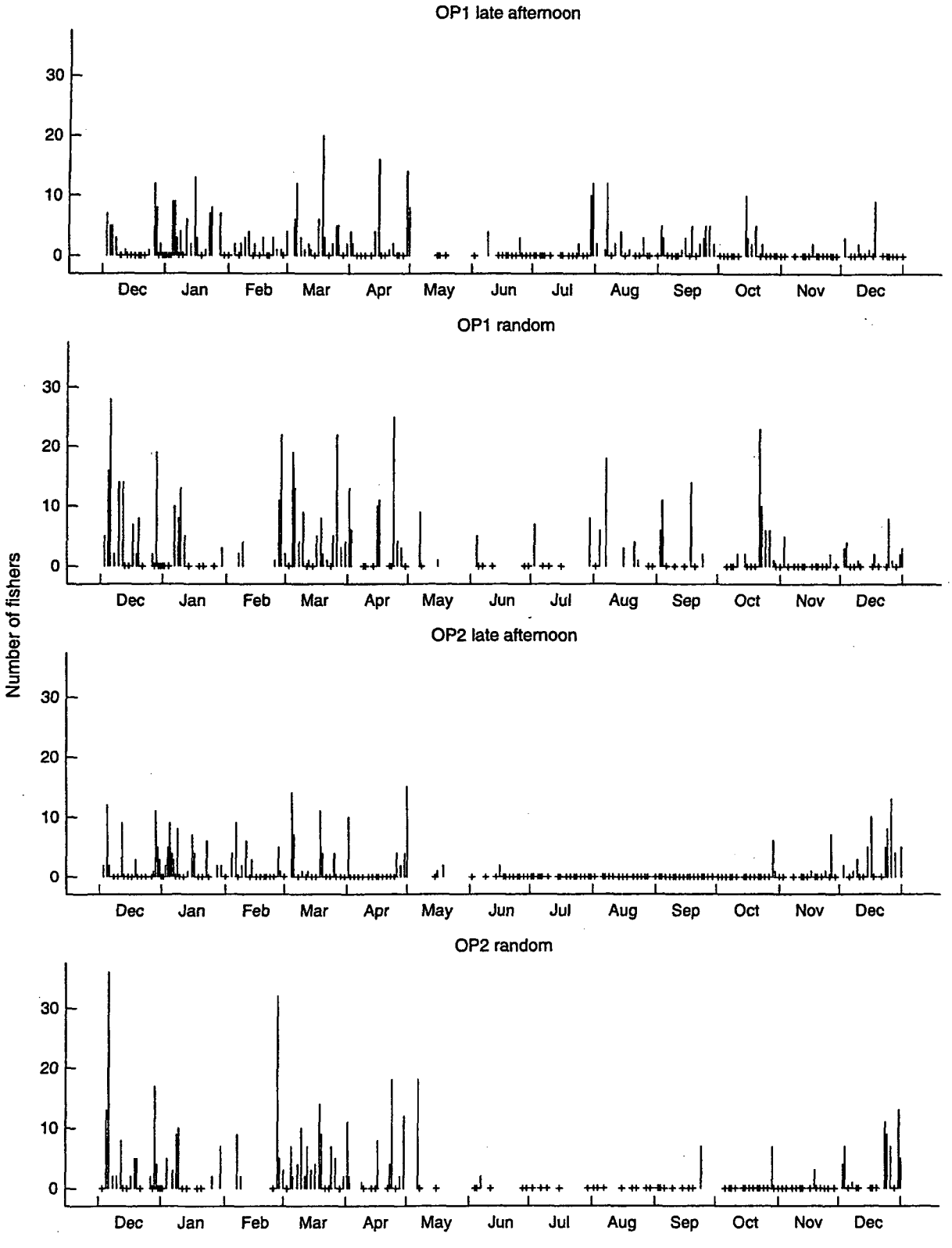

Figure 3: As for Figure 2, but for fishing localities OP1 and OP2 (the main boat fishing areas in the Taiapure, in Figure 1).

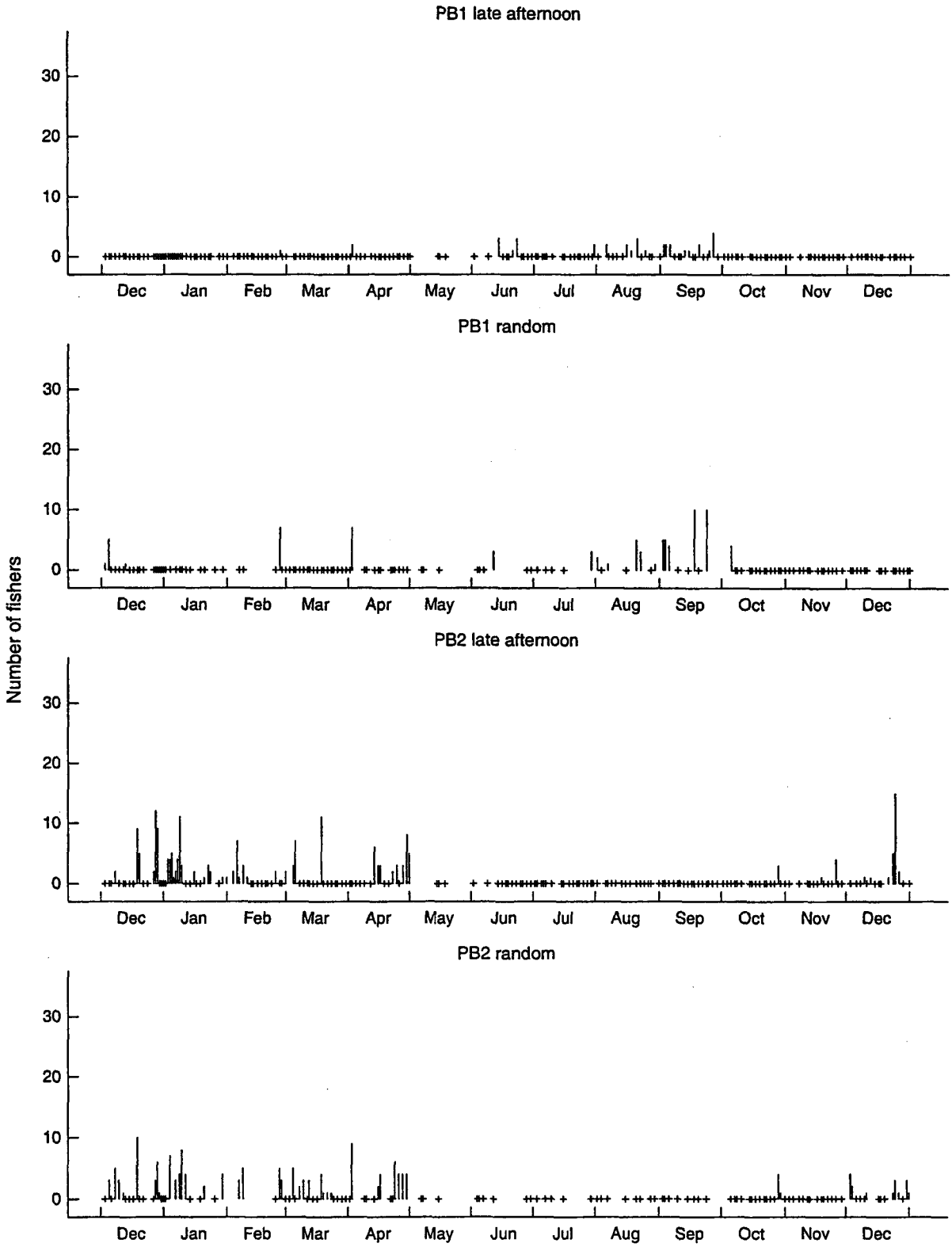

Figure 4: As for Figure 2, but for fishing localities PB1 and PB2 (the beaches extending east and west of the immediate Maketu area, in Figure 1).

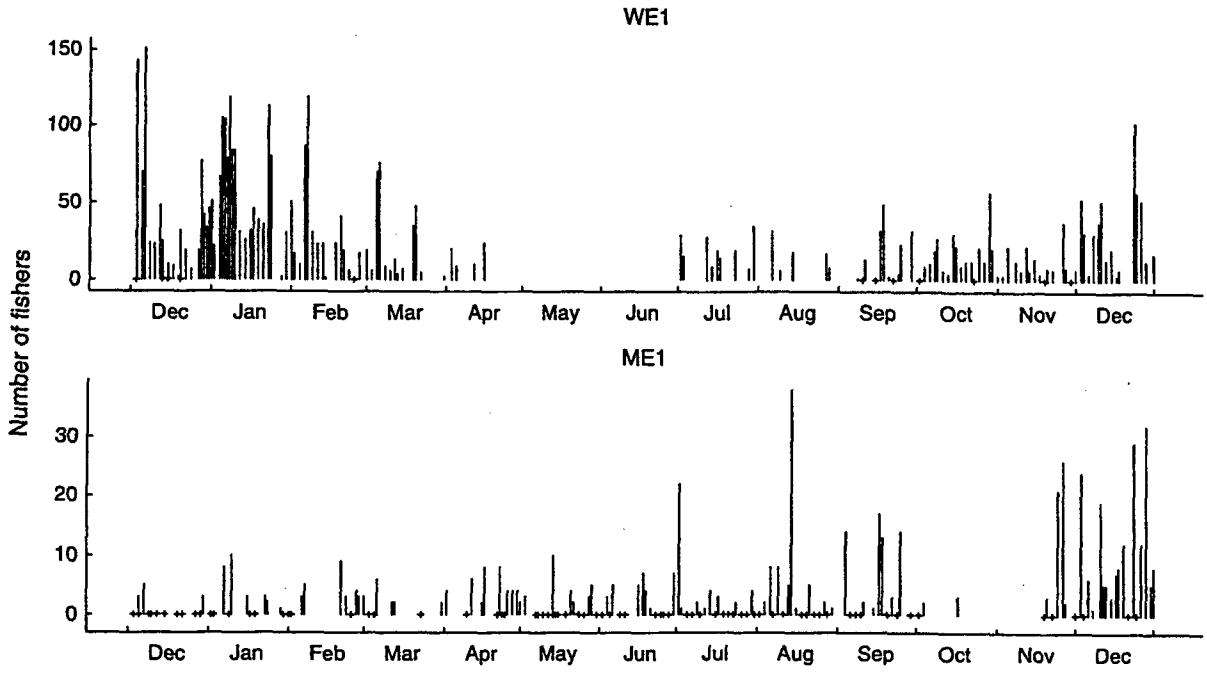

Figure 5: Numbers of fishers seen from LP3 (WE1 or Little Waihi Estuary) and LP2 (ME1 or Maketu Estuary) at low tide, December 1999–December 2000. +, no fishers seen.

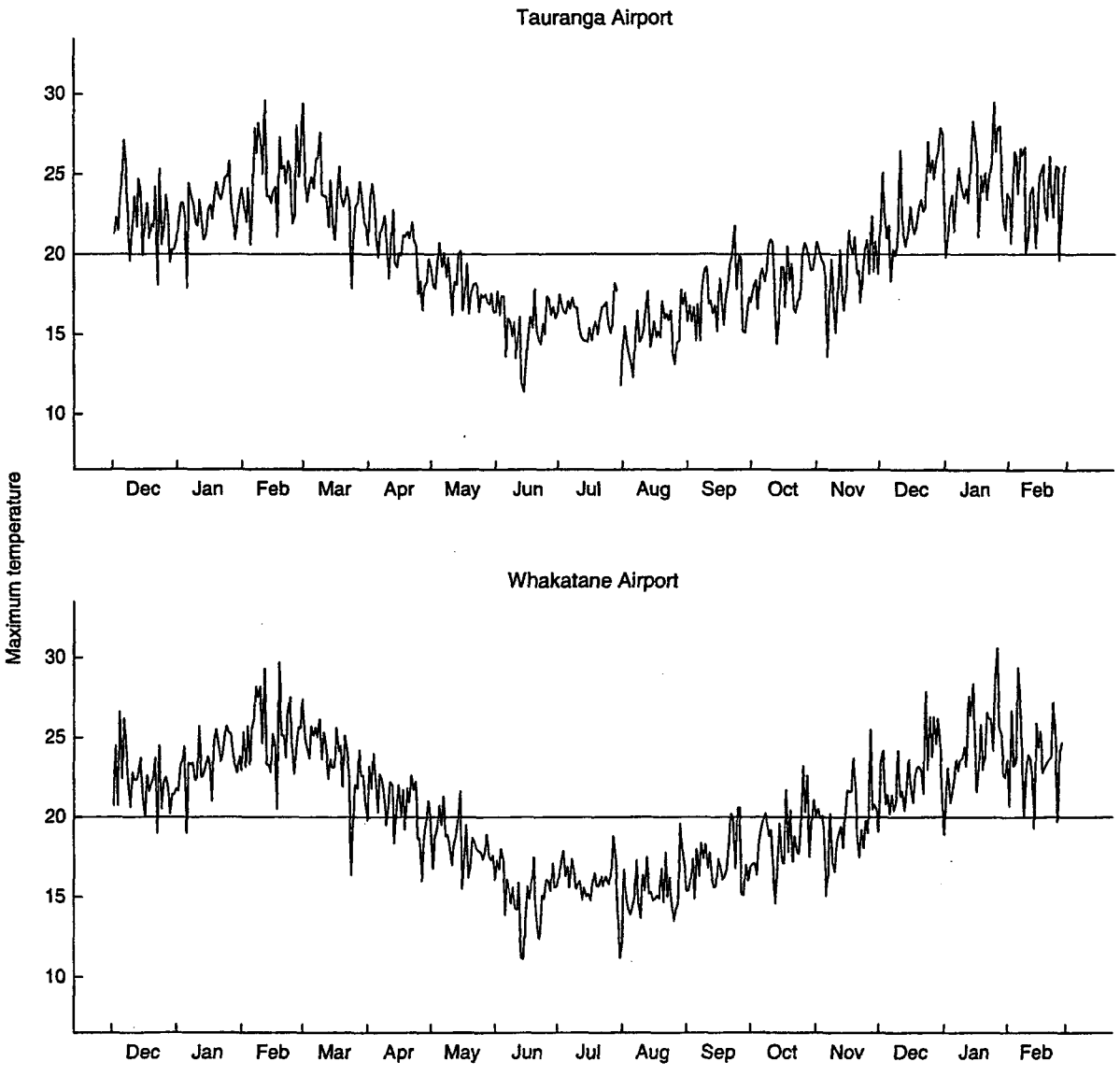

Figure 6: Daily maximum temperature at Tauranga and Whakatane Airports, December 1999–February 2001. The line at 20° was used in deciding how to divide the fishing year into two seasons.

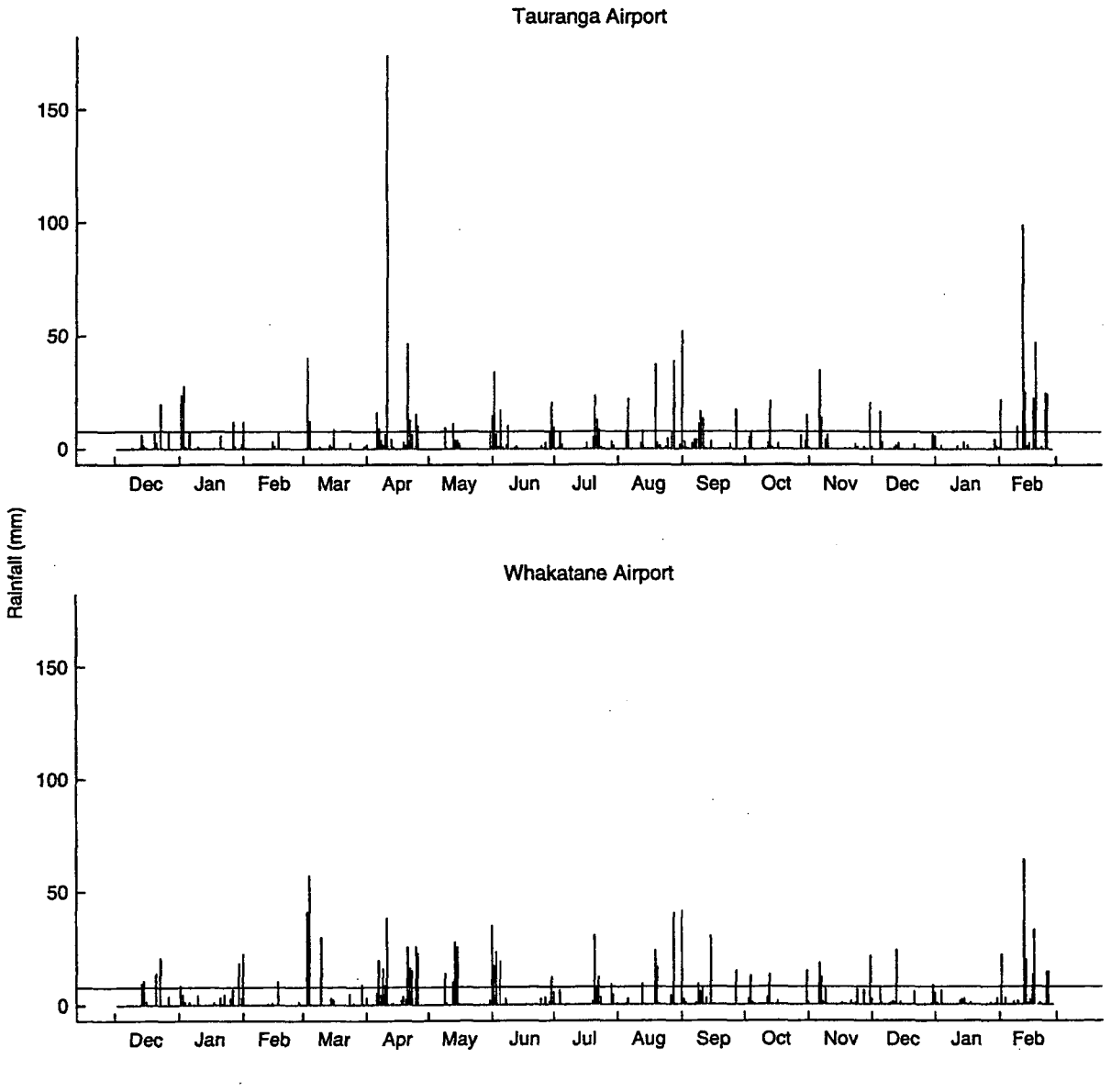

Figure 7: Daily rainfall at Tauranga and Whakatane Airports, December 1999–February 2001. The days with rainfall above the line at 7.5 mm may have reduced fishing effort.

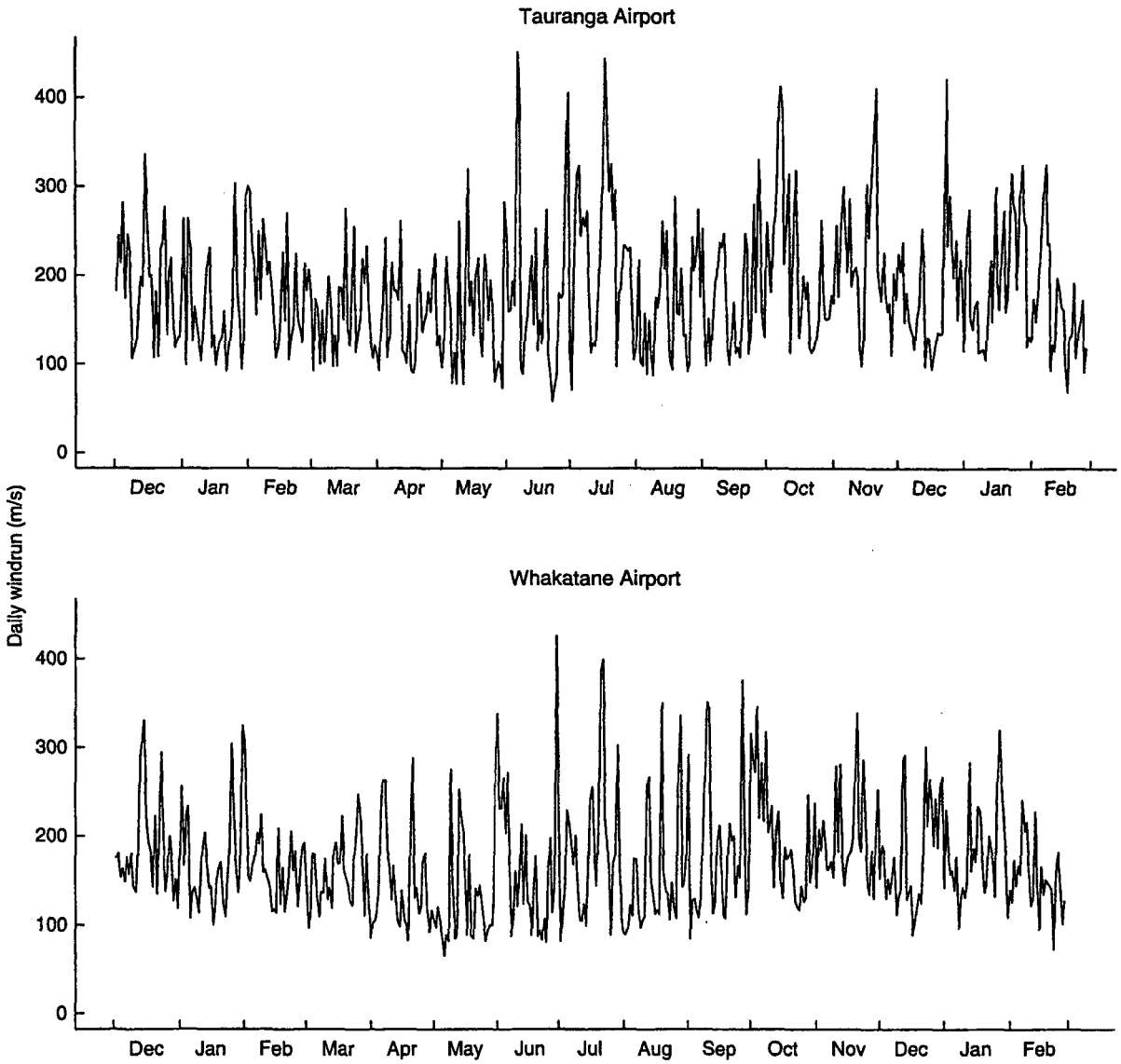

Figure 8: Daily windrun at Tauranga and Whakatane Airports, December 1999–February 2001.

APPENDIX 1:

Observer instructions for Maketu Taiapure Fishing Survey

An observation is a detailed snapshot by an observer of all fishing activity in the particular fishing area. The observer systematically observes and records all fishing parties, starting, say, in the north and ending in the south of the fishing area. Sometimes it will take just a couple of minutes to complete an observation, other times more because of the number of fishing parties in the fishing area. A fishing party is made up of fishers only; if there are people in the group who are clearly not fishing, then they are not recorded as being members of the fishing party.

The observations are recorded on the Observer Information Form. The form uses mainly coded information. The codes to use are explained below and on the form itself.

A. Day and environmental data

1. **Observer location:** location in words

2. **Observer name:** your name

3. **Observer location codes:**

LP1	Okurei Point
LP2	Maketu
LP3	Little Waihi
LP4	Pukehina South

4. **Observer time of day code:**

A	0600 - 1000	C	1400 - 1800
B	1000 - 1400	D	1800 - 2200

5. **Date:** use *ddmmyy* form (e.g. 091299 for 9 December 1999)

6. **Session start and finish time:** For all time data:
(1) record two numbers for the minutes (e.g. 0630 is correct, 6.3 incorrect) and (2) use 24 hour format (e.g. 2215).

7. **Day type code:**

1	Weekend or Public Holiday	2	Weekday

8. **Observer initials**: your initials.

9. **Sea conditions**

The sea conditions on the open coast are to be reported for Okurei Point and on the estuaries for Maketu and Little Waihi Estuaries.

10. Rain/Overhead conditions/Wind speed/Wind direction

Assess the conditions that occurred during the observation session and record according to the codes on page 3 of this guide.

B. Effort data

1. Party number: give a unique number to each fishing party observed, starting with 01. Do not include any commercial fishing operations.

2. Method: if the members of the party can be seen to be using differing fishing methods assign method

1 To the main activity
2 To the next important activity
3 ... (unlikely to be able to detect 3 or more activities for a party)

3. Method code: insert the appropriate two-letter method code from page 4.

4. Number of adults fishing in party: count

5. Number of (young) children fishing in party: count

6. Fishing area: Code for the fishing area from page 3 or the map.

C. Buoy counts:

This information is wanted to see if passive fishing operations such as rock lobster pots and setnets made by recreational or customary fishers can be detected.

1. Count any unattended marker buoys observed that are not marking a commercial fishing operation.
2. If the fishing method is obvious, insert the appropriate code from page 4.
3. Insert the fishing area code from page 3.

FISHING AREA CODES (*see* map)

PB1	Papamoa Beach to Kaituna Cut
KR1	Kaituna River
MB1	Maketu Estuary Beach
ME1	Maketu Estuary
OP1	West of line from Okurei Point to Motunau Is and out to 3 km
OP2	East of line from Okurei Point to Motunau Is and out to 3 km
WE1	Little Waihi Estuary
PB2	Pukehina Beach
OB1	Otamarakau Beach

OBSERVER LOCATION CODES

LP1	Okurei Point
LP2	Maketu
LP3	Little Waihi
LP4	Pukehina South

ENVIRONMENTAL CODES:

Sea conditions

1	Smooth (0.1 – 0.5 m)	3	Moderate (1.0 – 2.5 m)
2	Slight (0.5 – 1.0 m)	4	Rough (2.5 – 4.0 m)

Rain

1	Nil	3	Light scattered
2	Light continuous	4	Medium scattered

Overhead conditions

1	Sunny continuous	3	Mainly cloudy
2	Mainly sunny	4	Continuous cloud

Wind speed

1	Nil	3	Medium (11 – 20 kts)
2	Light (1 – 10 kts)	4	Strong (21+ kts)

Wind direction

1	Nil (No wind)	6	Southwest
2	Variable	7	East
3	North	8	West
4	South	9	Southeast
5	Northeast	10	Northwest

FISHING METHODS

BA	*Baitfishing*
JI	*Jigging*
T	*Trolling*
RS	*S/cast (rocks & sand)*
WH	*Groyne fishing*
KO	*Kon tiki*
LU	*Line fishing (unspec)*
DD	*Dredging*
DN	*Drag netting*
HA	*Hand gather (eg pipi)*
PT	*Potting (ie. Crayfish)*
DI	*Diving unspecified*
SN	*Set netting*
DS	*Dive (spear fishing)*
PA	*Setting/retrieving pots*
NA	*Setting/retrieving nets*
WB	*Whitebaiting – scoop*
WS	*Whitebaiting – static*

APPENDIX 2: SAMPLE DATES AND TIMES FOR OBSERVERS

Observers: LP1 and LP4

Day	Date	Random time	Evening
Saturday	July 1	1430	1700
Sunday	July 2	1230	1700
Tuesday	July 4	1230	1700
Thursday	July 6	2030	1700
Saturday	July 8	1230	1700
Sunday	July 9	0830	1700
Tuesday	July 11	1330	1700
Thursday	July 13	0830	1700
Saturday	July 15	1430	1700
Sunday	July 16	1630	1700
Tuesday	July 18	1530	1700
Thursday	July 20	1230	1700
Saturday	July 22	1830	1700
Sunday	July 23	1430	1700
Tuesday	July 25	1330	1700
Thursday	July 27	1830	1700
Saturday	July 29	1030	1700
Sunday	July 30	1730	1700
Tuesday	August 1	0730	1700
Thursday	August 3	0730	1700
Saturday	August 5	1030	1700
Sunday	August 6	1230	1700
Tuesday	August 8	1730	1700
Thursday	August 10	1830	1700
Saturday	August 12	0730	1700
Sunday	August 13	0730	1700
Tuesday	August 15	0730	1700
Thursday	August 17	1630	1700
Saturday	August 19	1830	1700
Sunday	August 20	1230	1700
Tuesday	August 22	0930	1700
Thursday	August 24	1730	1700
Saturday	August 26	1930	1700
Sunday	August 27	0930	1700
Tuesday	August 29	1530	1700
Thursday	August 31	1630	1700
Saturday	September 2	1430	1700
Sunday	September 3	0930	1700
Tuesday	September 5	1530	1700
Thursday	September 7	1730	1700
Saturday	September 9	1330	1700
Sunday	September 10	1030	1700
Tuesday	September 12	1330	1700
Thursday	September 14	0730	1700
Saturday	September 16	0930	1700
Sunday	September 17	1030	1700
Tuesday	September 19	0930	1700
Thursday	September 21	1930	1700
Saturday	September 23	0730	1700
Sunday	September 24	1230	1700
Tuesday	September 26	1230	1700
Thursday	September 28	1730	1700
Saturday	September 30	1630	1700

Observers: Estuaries (LP2 and LP3)

Day	Date	Low tide
Saturday	July 1	1130
Sunday	July 2	1230
Tuesday	July 4	1400
Thursday	July 6	1600
Saturday	July 8	1800
Sunday	July 9	1830
Tuesday	July 11	0800
Thursday	July 13	1000
Saturday	July 15	1200
Sunday	July 16	1230
Tuesday	July 18	1400
Thursday	July 20	1500
Saturday	July 22	1600
Sunday	July 23	1700
Tuesday	July 25	1830
Thursday	July 27	0800
Saturday	July 29	1000
Sunday	July 30	1100
Tuesday	August 1	1300
Thursday	August 3	1500
Saturday	August 5	1630
Sunday	August 6	1730
Tuesday	August 8	0700
Thursday	August 10	0830
Saturday	August 12	1030
Sunday	August 13	1100
Tuesday	August 15	1230
Thursday	August 17	1400
Saturday	August 19	1500
Sunday	August 20	1600
Tuesday	August 22	1730
Thursday	August 24	0700
Saturday	August 26	0900
Sunday	August 27	1000
Tuesday	August 29	1200
Thursday	August 31	1330
Saturday	September 2	1530
Sunday	September 3	1600
Tuesday	September 5	1730
Thursday	September 7	0700
Saturday	September 9	0900
Sunday	September 10	0930
Tuesday	September 12	1130
Thursday	September 14	1300
Saturday	September 16	1400
Sunday	September 17	1500
Tuesday	September 19	1600
Thursday	September 21	1800
Saturday	September 23	0730
Sunday	September 24	0830
Tuesday	September 26	1030
Thursday	September 28	1230
Saturday	September 30	1400

APPENDIX 3:

Interviewer instructions for the Maketu Taiapure Fishing Survey

An interview is when an interviewer asks questions of a fishing party about their recent or current fishing activity. Interviews take place as fishing parties leave or prepare to leave boat ramps, car park and access areas, and wharfs (The Groyne), or during fishing or gathering activity on beaches or in estuaries. The aim is to interview as many fishing parties as possible during an interview session, each of which normally lasts about 4 hours. Interview sessions should be aimed at the times when the most fishing parties will be available for interview.

A fishing party is made up of fishers only. If there are people in the group who clearly have not been fishing, or who are not fishing, then they are not considered to be members of the fishing party.

Most of the interview information on the forms provided is entered as codes. All codes are given on the forms, in the lists provided, or in these instructions. Many of the interviews will take place near ramps. At a boat ramp, you want to meet the party just after they have left the ramp to avoid congestion on the ramp.

Some notes on introducing yourself

The initial introduction is important and frequently can determine the success of the interview. You should introduce yourself in the following manner. *"Hello my name is ... and I am doing a survey of fishing within the Maketu Taiapure. Can I ask you a few questions about your fishing today? First, were you fishing within the Taiapure?"* You may wish to emphasise that the interview has nothing to do with fisheries compliance. Describe how long the session is likely to take.

You may also need to explain the area included in the Maketu Taiapure. Use the map on the back of the form to help establish where fishing took place.

If the answer was *"No"*, that is the end of the interview. Enter X in the Interview outcome box in the Interview Session Cover Form.

If the answer is "*Yes*", continue with the interview.

Sometimes the fishers will want to know why you are doing the survey. Therefore reply ... *"We want to know more about recreational and customary fishing in the Taiapure area such as the main species caught and how many, the main fishing methods, and where people are fishing".*

Interview Session Cover Form

Record all fishing parties present at the Interview location during this session, whether you interviewed them or not.

1. **Interview** grouping: in words (Ramp 1, Ramp 2, Ramp 3, Shellfish, or Roving Beach)

2. **Interviewer name:** your name

3. **Session time start (and finish)**
   Use codes below when the start (finish) of the interview falls within the designated times.

A	0600 - 1000	C	1400 - 1800
B	1000 - 1400	D	1800 – 2200

4. **Time recording conventions**
   Record the date in *ddmmyy* format and use a 24 hour clock for all times. That is, for all time data: (1) record two numbers for the minutes (e.g. 0630 is correct, 6.3 incorrect) and (2) use 24 hour format (e.g. 2215).

5. **Day type codes**

Weekend or Public holiday		2	Weekday

6. **Interviewer initials:** your initials

7. **Interview location code:** *see* codes on page 9 of this guide

8. **Session number:** gives each group of interviews in the session a unique character, which allows direct linkage to the party data below and the Fishing Method and Count Form.

9. **Interview type:** code as follows: 1= Ramp, 2= Beach, 3 = Estuary, 4 = Groyne

10. **Time start, Time finish:** these are for the time you spent at that particular Interview location

11. **Party data:** you need to make an entry for every party observed at the Interview location, whether you interview them or not.

12. **Session number**: allows direct link with 8 above and the Fishing Method and Count Form.

13. **Party number**
    A number is to be assigned to each party (beginning at 01) present in this interview session, whether they were interviewed or not. Record the fisher and catch information for each party on a separate Fishing Method and Count Form. After interviewing the fishers in a party you may need to spend a few minutes to ensure that the data are recorded correctly.

If several parties are present at once, it may be impossible to interview them all. In these situations, it is better to miss a party or two and make sure that the data are accurately recorded and legible, rather than attempt to intercept every party. Keep a record of *all* parties, including the parties that were not intercepted (using the codes outlined below), on the bottom half of the Interview Session Cover Form.

14. Party type code

R	Recreational boat	M	Customary boat
S	Recreational shore	N	Customary shore

15. Interview outcome code

I	Interviewed	O	Other
R	Refused to be interviewed	X	Outside Maketu Taiapure area
N	Not interviewed	Z	Incomplete (roving) interview

16. Time of interview

For each party, record the time that either the party was interviewed or the time that the party returned. For all time data: (1) record two numbers for the minutes (e.g. 0630 is correct, 6.3 incorrect) and (2) use 24 hour format (e.g. 2215).

17. No. in party

For each party, record the number of fishers. Remember, a fishing party is made up of only the fishers.

Fishing Method and Count Form

One of these forms is completed for each party interviewed. The top line of boxes repeats some of those on the Interview Session Cover Form.

1. **Fisher home town**
   Can you please tell me the place where you live?
   If people come from more than one place, use the one from which most people come. The answers will later be coded into "local to the area" or "outside the area".

2. **Fisher Number**
   "How many people were fishing in your party today?"
   Assign a number to each person fishing in the party. If you are not certain whether or not fishers have been fishing that day, then ask *"Have you been fishing today?"*

3. **Location/method/target (LMT)**
   Because catch rates may vary depending upon (a) where the fishing was done, (b) the fishing method used, and (c) the target species, we need to collect separate catch and effort data when any of these three factors vary over a day's fishing. For example, a fisher may have target fished for snapper in the morning using jigs, and then in the afternoon targeted kahawai by trolling somewhere else. We call each fishing location/method/target combination on a single fishing trip a "LMT". If more than one combination is used, then it is very important that this information is recorded separately. Record the first combination with an "A" in the LMT column. The second combination would be recorded with a "B". "C" would be recorded in the rare situation involving three combinations.

4. **Fishing area**
   "Were you fishing within the Maketu Taiapure today?" "Roughly where?"

   Maps and codes defining the fishing areas are provided on the back of each Session form and also on page 9 of this document. Capital letters are used for all area codes. Do not record data for a fishing area that was fished for less than 15 minutes.

   If fishing alternated between two or more distinct areas (e.g. in areas OP1 and OP2) and it is too complicated to unravel the fishing patterns, then the area in which most activity took place should be recorded as the fishing area.

5. **Fishing method**
   "What was the main fishing method you used today?"

   Capital letters are used for all method codes, as provided on page 10. Do not record data for a fishing method that was used outside the Maketu Taiapure area or for less that 15 minutes. Note that bait fishing includes live baits, or using a bait on a floating line.

Frequently, the fishers will not understand this question and may reply "rod and reel". When this happens, it will be necessary for you to use a prompt, for example, by asking the question: *"Was it trolling or jig fishing with a rod and reel?"*

Trolling should usually be used as the prompt because the fishers will often forget that they had done half an hour to an hour's trolling (usually for kahawai), when most of the time was spent bait fishing on the bottom. Note that for trolling, the fishing effort data are to be recorded against each fisher who was in control of a line.

6. Target species

"Were you fishing for any particular species of fish today?"
It is important that you state this question very specifically.

Capital letters are used for all species codes (according to the list on page 11). You should not record data for target species that were fished for less than 15 minutes.

Frequently, the fishers will not understand this question. The fishers may provide a number of confusing replies, in which case you will need to ask some additional questions.

If the fishers reply *"Anything"* or *"Fish"*, you should prompt by asking the question *"Was it jack mackerel?"* Jack mackerel is suggested as few non-commercial fishers target jack mackerel. If the answer is still *"Anything"* or *"No"*, then the species code would be recorded as MIX (mixed fish).

If a number of species were all mentioned in quick succession, then the species that was mentioned first should be recorded as the target.

If there definitely was more than one target species, then for the fisher concerned, each target species should be recorded on a separate line. For the first target species, record an "A" in the LMT column after the fisher's number. For the second target species, record a "B" - on the next line of the LMT column.

7. Time start

"At what time did you start fishing today, that is, you put your lines in the water, began diving, or started gathering?"

It is important to be specific about what is meant by the start time so that fishers do not give the time they left home or left the ramp. You should record the time to the nearest quarter of an hour. If the reply is given as a range of numbers, for example, *"7 to 8"*, then record the answer as 0730.

For setnets, longlines, or craypots etc. that have been set overnight, record the start time as 0000. For fishers fishing throughout the night, record only the fishing effort and catch data relevant to the day of interview.

For parties that have been fishing for more than one day, differentiate the catch and fishing effort into separate days. Treat each day's catch as though it had been caught by a separate party.

8. Time finish

"At what time did you finish fishing today?"

Finished fishing means pulling the lines, pots, or nets out of the water, or stopped gathering. Time is recorded to the nearest quarter of an hour. For roving interviews, enter the Time of intercept as the Time finish.

9. All the same

"Were you all fishing for approximately the same time today?"

Record Y = yes or N = no. In general, most people in a party are fishing and fish the same length of time as each other – particularly when in boats.

10. Time not fishing

Time not fishing within the Maketu Taiapure area should be included.

Find out, to the nearest 15 minutes, any time on this trip spent outside the Taiapure.

11. Days/year

"How many days have you been fishing in the last year (since this time last year)?"

This can sometimes be a very difficult question for a fisher to answer. It may be necessary to prompt the fisher by asking *"Was it 5, 20, or 50 times?"* Generally, you will need to ask each fisher. Ask this question only for the main LMT.

12. Fish counts and measurements

Counts are required for all species caught, but measurements are required only for fin-fish (excluding whitebait), crayfish, and paua. While counts are always required, sometimes there will not be time to measure all the fish.

"May I please inspect your catch so that I can record counts and measurements of your fish?"

"As best you can remember, please divide this catch up amongst each of you who caught the fish?"

In general the best place to measure the fish is at the top of the boat ramp after the boat has been hauled out of the water, and the boat is being prepared for the road.

To avoid getting your hands messy and to speed up the interview, ask one of the fishers to handle the fish and put the fish on the measuring board. But do not ask the fisher to read the length measurement as fishers have a tendency to round

measurements to the nearest 5 cm. It is very important that you read and record the length measurement.

Record the species code and length against the appropriate fisher number and LMT as the fish are measured. Attempt to measure all the fish of a particular species, including undersized fish. Give priority to commonly caught species.

If many fish were caught by the party, it may be difficult (if fishers could not remember) to definitively link each fish with the actual person who caught the fish. In these situations, divide the fish amongst the fishers as best you can.

13. Measurement method (MM) codes

1 Fork length (to the fork of the tail)	Most species (eg snapper, kahawai)
2 Total length (to the tip of the tail)	John dory and some sharks
3 Standard length	Very rare (orange roughy)
4 Pelvic length (tip of nose to start of tail)	Eagleray, stingray
5 Tail width	Crayfish (both red and packhorse)
6 Shell length	Paua (both black foot and yellow foot)

Measure finfish in centimetres (round down to the nearest centimetre below). Measure both species of crayfish across the width of the tail (*see* enclosed amateur fishing rules) to the nearest millimetre below, using the callipers provided. Crayfish should also be sexed. Paua are also measured to the nearest millimetre below, using the maximum shell length determined with calipers.

14. Fish not measured – use the *observed* and count *columns*

There will always be full fish and shellfish counts, but in some cases it will not be possible to measure all the fish. Therefore, record 2 (= fish counted) in the "Observed" column, obviously leaving the Length column blank. Record the number of fish that were counted in the "Count" column.

Record 3 (= fish observed) in an Observed column when a fisher has caught a particularly large amount of shellfish (sometimes also flounder) and you do not have time to count all the animals, but you *observed* that there were about how many the fisher said there were in the catch bag or fish bin.

Record 4 (= fish not observed) for fish that you did not actually get to see but did not fall into any of the other observed categories explained below.

In all of these situations, remember to record the number of fish involved in the Count column.

No subsampling

Do not subsample the catch, that is, do not measure just the big fish, or not measure fish that may not be legal. For each species, either measure all the fish or count all the fish. However, you can mix the species. For example, for a particular party, you could measure the kahawai caught, but just count the trevally and the gurnard.

15. Other *Observed* column codes

Fish – fillets, bait, and live and dead throwbacks

Remember to ask these important questions for other fish that may have been caught.
"Did your party catch any fish that . . .

. . . were filleted (including headed fish)?"	Code = F in the observed column
. . . were used for bait?"	Code = B in the observed column
. . . were returned to the sea?"	
. . . . . were they alive?"	Code = A in the observed column
. . . . . were they dead?"	Code = D in the observed column

If the answer is "yes", record the appropriate fish count, LTM, and species code for the fisher concerned.

Crayfish – sex

Sex the crayfish using the information in the attached amateur fisheries regulations.

If male	Code = X in the observed column
If female	Code = Y in the observed column

FISHING AREA CODES (*see* map)

PB1	Papamoa Beach to Kaituna Cut
KR1	Kaituna River including the Groyne
MB1	Maketu Estuary Beach
ME1	Maketu Estuary
OP1	West of line from Okurei Point to Motunau Is and out to 3 km
OP2	East of line from Okurei Point to Motunau Is and out to 3 km
WE1	Little Waihi Estuary
PB2	Pukehina Beach
OB1	Otamarakau Beach

OBSERVER LOCATION CODES

LP1	Okurei Point
LP2	Maketu
LP3	Little Waihi
LP4	Pukehina South

INTERVIEW LOCATION CODES

Ramps

KR4	Bell Road
KR3	Boy's
ME2	Maketu
WE2	Little Waihi

Car park and access areas

WE3	Little Waihi
ME3	Maketu
ND1	Top of Newdick's Road

The Groyne

KR2	The Groyne (Kaituna R)

Beaches

PB3	Pukehina East
PB4	Pukehina West
OB2	Overhead Bridge Access
OB3	Rogers Road
OB4	Otamarakau
MB1	Maketu Beach

Estuaries

ME4	Maketu
WE4	Little Waihi

FISHING METHODS

BA	Baitfishing
JI	Jigging
T	Trolling
RS	S/cast (rocks & sand)
WH	Groyne fishing
KO	Kon tiki
LU	Line fishing (unspec)
DD	Dredging
DN	Drag netting
HA	Hand gather (eg pipi)
PT	Potting (ie. Crayfish)
DI	Diving unspecified
SN	Set netting
DS	Dive (spear fishing)
PA	Setting/retrieving pots
NA	Setting/retrieving nets
WB	Whitebaiting – scoop
WS	Whitebaiting – static

SPECIES CODES

ALB	Albacore tuna	PAR	Parore/black snapper
BAR	Barracouta	PAI	Paua (black foot)
BAS	Bass	PAA	Paua (yellow foot)
BCO	Blue cod	PAU[1]	Paua (general)
EMA	Blue mackerel	PHC	Packhorse crayfish
MOK	Blue moki	PMA	Pink maomao
BWS	Blue shark	POR	Porae
BPE	Butterfly perch	SPO	Rig/Spotted dogfish
BPF	Banded wrasse	RMO	Red moki
BOA	Boarfish	RMU	Red mullet/goatfish
BMA	Blue maomao	RPI	Red pigfish
BNS	Bluenose	ROC	Rock cod
BWH	Bronze whaler	RRC	Red scorpionfish
SKJ	Bonito /skip jack tuna	RSN	Red/golden snapper
CON	Conger eel	SPF	Scarlet wrasse
CRA	Crayfish (red)	SCH	School shark
PHC	Crayfish (packhorse)	SKA	Skate
EGR	Eagle ray	SKJ	Skipjack tuna/bonito
EEU[1]	Eel (freshwater)	SNA	Snapper
EMA	English (blue) mackerel	SPD	Spiny dogfish
FLA	Flatfish	SPO	Rig/Spotted dogfish
GAR	Piper/Garfish	STA	Stargazer
SKI	Gemfish	STM	Striped marlin
RRC	Grandaddy hapuka	STR	Stingray
SWE	Grey maomao (sweep)	STY	Spotty
GMU	Grey mullet	SWE	Sweep
GUR	Gurnard/red gurnard	SWR	Sandagers wrasse
KEL	Hiwihiwi/kelpfish	TAR	Tarakihi
HHS	Hammerhead shark	TRE	Trevally
BAS	Bass groper	TRU	Trumpeter
HAP	Hapuka	WSE	Wrasse
HPB[1]	Hapuka/bass	YEM	Yellow eye mullet
JMA[1]	Jack mackerel	YFN	Yellowfin tuna
JMD	*Trachurus declivis*	WHI	Whitebait
JMM	*T. murphyii*		
JMN	*T. novaezaelandiae*	COC	Cockles
JDO	John dory	DAN	(Ringed) *Dosinia anus*
KAH	Kahawai	HOR	Horse mussels
KEL	Kelpfish	MUS[1]	Mussels (general)
KIN	Kingfish	MSG	Green mussels
KOH	Koheru	MSB	Blue mussels
LEA	Leatherjacket	OUN[1]	Oysters (general)
LFB	Long-finned boarfish	POY	Pacific oysters
MAK	Mako shark	PPI	Pipi
MIX[2]	Fish (as target species)	SCA	Scallops
MOK	Moki (blue moki)	SAE	Triangle shell
MOR	Moray eel	SUR	Kina
OCT	Octopus	TUA	Tuatua

[1] some general codes are given where species are assessed together. If possible use the specific code, but do not guess. For example, you can probably identify *T. murphyii* (JMM), but not the two endemic species.
[2] MIX is a code for any fish and should be used for target specie only.

APPENDIX 4: SAMPLE INTERVIEW PROGRAMME

Time and type of interview session. The location defines the location of the interview or the circuit to be followed by the interviewer. Times were selected each three months.

Day	Date	Interview type	Location
Saturday	July 1	Shellfish	Waihi; car park; Newdick's
Sunday	July 2	Shellfish	Waihi; car park; Newdick's
Saturday	July 8	Ramp 3	Maketu
Sunday	July 9	Ramp 3	Maketu
Saturday	July 15	Roving Beach	Around beach access points
Sunday	July 16	Roving Beach	Around beach access points
Saturday	July 22	Ramp 2	Boy's; Groyne; Beach
Sunday	July 23	Ramp 1	Bell Road
Saturday	July 29	Ramp 3	Maketu
Sunday	July 30	Ramp 3	Maketu
Saturday	August 5	Ramp 2	Boy's; Groyne; Beach
Sunday	August 6	Ramp 2	Boy's; Groyne; Beach
Saturday	August 12	Roving Beach	Around beach access points
Sunday	August 13	Ramp 2	Boy's; Groyne; Beach
Saturday	August 19	Ramp 2	Boy's; Groyne; Beach
Sunday	August 20	Roving Beach	Around beach access points
Saturday	August 26	Ramp 1	Bell Road
Sunday	August 27	Ramp 1	Bell Road
Saturday	September 2	Ramp 1	Around beach access points
Sunday	September 3	Ramp 1	Bell Road
Saturday	September 9	Ramp 2	Boy's; Groyne; Beach
Sunday	September 10	Shellfish	Waihi; car park; Newdick's
Saturday	September 16	Ramp 1	Bell Road
Sunday	September 17	Roving Beach	Around beach access points
Saturday	September 23	Ramp 3	Maketu
Sunday	September 24	Shellfish	Waihi; car park; Newdick's
Saturday	September 30	Shellfish	Waihi; car park; Newdick's

APPENDIX 5. DEFINITIONS

Let i = 1,2, ..., N, x_i = trip length of the ith angler or party in hours (fishing effort), y_i = harvest by the ith angler or party, n = number of anglers or parties interviewed, and N = number of anglers or parties in the fishery on a given day (or in a given time period). The following definitions are used. They are standard and based on material given by Jones *et al.* (1995).

$\bar{x} = \sum_{i=1}^{n} x_i / n$ = sample mean of angler party effort;

$\bar{y} = \sum_{i=1}^{n} y_i / n$ = sample mean of angler or party harvest;

$s_x^2 = \sum_{i=1}^{n} (x_i - \bar{x})^2 / (n-1)$ = sample variance of angler or party effort;

$s_y^2 = \sum_{i=1}^{n} (y_i - \bar{y})^2 / (n-1)$ = sample variance of angler or party catch;

$c_x = s_x / \bar{x}; c_y = s_y / \bar{y}$; *c.v.*s of the effort and catch;

$h_i = y_i / x_i$ = harvest rate of angler or party.

The mean-of-ratios harvest rate is defined by

$H_1 = \sum_{i=1}^{N} h_i / N$ and is estimated by

$\hat{H}_1 = \sum_{i=1}^{n} h_i / n$ = per-angler or per-party estimator of mean harvest rate. The values of h_i can be in error, mainly due to errors in estimating the effort, leading to bias in $\hat{H}_1$. Bias from this cause is likely for short trips, particularly those with high catch (Pollock *et al.* 1997).

The exact variance of $\hat{H}_1$ is given by

$$V(\hat{H}_1) = \sum_{i=1}^{N} (y_i / x_i - H_1)^2 / nN$$

which contains H_1 rather than its estimator, and the sum is over all anglers or parties. The estimator used for the variance of $\hat{H}_1$ is

$\hat{V}(\hat{H}_1) = \sum_{i=1}^{n} \left(h_i - \hat{H}_1\right)^2 / n(n-1)$, and its *c.v.* is

$c.v.(\hat{H}_1) = \sqrt{\hat{V}(\hat{H}_1)} / \hat{H}_1$.

The ratio-of-means harvest rate is defined as

$H_2 = \sum_{i=1}^{N} y_i / \sum_{i=1}^{N} x_i$. The means are implicit as the population size cancels out. H_2 is

estimated by

$$\hat{H}_2 = \sum_{i=1}^{n} y_i \Big/ \sum_{i=1}^{n} x_i .$$

The approximate variance of the ratio-of-means estimator is given by (Cochran 1977, p. 153)

$$V(H_2) \cong \frac{1}{(n\bar{X})^2}\left[\frac{\sum_{i=1}^{N}(y_i - H_2 x_i)^2}{N}\right].$$

where $\bar{X}$ is the mean effort of all fishers or parties.

There are several forms for estimators of the variance of $\hat{H}_2$. One is calculated using Fieller's theorem (Cochran 1977, p. 156)

$$\hat{V}(\hat{H}_2) = s_y^2 + H_2^2 s_x^2 - 2H_2 s_{xy}\big/(n\bar{x}^2) \quad \text{where} \quad s_{xy} = \sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})\big/(n-1).$$

This estimator contains the true value, H_2, and where necessary in the various simulations performed, we use the value of H_2 from the data set on which the simulations are based as the true value of H_2.

We have opted to use a bootstrap estimate of this variance of the ratio-of-means estimator in this report. The numbers 1 to n (the sample size) are re-sampled with replacement 1000 times to define the reordering of both the harvest and effort data in each bootstrap estimate of the ratio-of-means harvest rate. The standard error is estimated from the variance of the bootstrap distribution.

APPENDIX 6: RECORDING FORMS

MAKETU TAIAPURE FISHING SURVEY
OBSERVER INFORMATION FORM

NIWA
Taihoro Nukurangi

Observer location: _____ Observer name: _____

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

1=Weekend or Public holiday
2=Weekday

Environmental data:

Sea conditions	Rain	Overhead conditions	Wind speed	Wind direction
1=Smooth (0.1 - 0.5m)	1=Nil	1=Sunny continuous	1=Nil	1=Nil (no wind)
2=Slight (0.5 - 1.0 m)	2=Light continuous	2=Mainly sunny	2=Light (1-10 kts)	2=Variable
3=Moderate (1.0 - 2.5m)	3=Light scattered	3=Mainly cloudy	3=Medium (11-20 kts)	3=North
4=Rough (2.5 - 4.0m)	4=Medium scattered	4=Continuous cloudy	4=Strong (21 + kts)	4=South
				5=Northeast
				6=Southwest
				7=East
				8=West
				9=Southeast
				10=Northwest

Effort data:

Party No.	Activity	Method Code	No. Adults	No. Children	Fishing Area

Party No.	Activity	Method Code	No. Adults	No. Children	Fishing Area

Buoy counts:

No. of Buoys	Method Code	Fishing Area

NIWA
Taihoro Nukurangi

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MAKETU TAIAPURE FISHING SURVEY
INTERVIEW SESSION COVER FORM

Interview grouping: _____ Interviewer's name: _____

Date	Session time start (24hr)	Session time finish (24hr)	Day type	Interviewer's initials
d d m m y y			1 = Weekend or public holiday 2 = Weekday	

Interview location code	Session number	Interview time of day code	Interview type	Time start (24hr)	Time finish (24hr)
	1		1=Ramp 2=Beach 3=Estuary 4=Groyne		
	2				
	3				
	4				
	5				
	6				
	7				

Party data:

Interview location	Session number	Party number	Party type	Interview outcome	Time of interview (24hr)	No. in party

Interview location	Session number	Party number	Party type	Interview outcome	Time of interview (24hr)	No. in party

MAKETU TAIAPURE FISHING SURVEY
FISHING METHOD AND COUNT FORM

NIWA Taihoro Nukurangi

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Interview location code	Session no.	Time of day code	Date (d d m m y y)	Party no.	Party type	Interview outcome	Time of interview (24 hour)

Fisher home town: ______________________________

Fisher No.	LMT	Fishing area	Fishing method	Target species	Time start (24 hour)	Time finish (24 hour)	All the same	Time not fishing Hrs	Mins	Days/year

Fisher No.	LMT	Species	Length (cm)	MM	Count	Observed*

Fisher No.	LMT	Species	Length (cm)	MM	Count	Observ

*Observed 1=measured 2=counted 3=observed 4=not observed F=fish filleted B=fish used for bait A=returned alive D=returned dead X=male rock lobster Y=female rock lobster

Version date: 24/3/00