Recreational harvest estimates for SNA 8 in 2006–07

B. Hartill
M. Vaughan
N. Rush

NIWA
Private Bag 99940
Auckland 1149

New Zealand Fisheries Assessment Report 2011/51
November 2011

Published by Ministry of Fisheries
Wellington
2011

ISSN 1175-1584 (print)
ISSN 1179-5352 (online)

Hartill, B.; Vaughan, M.; Rush, N. (2011).
Recreational harvest estimates for SNA 8 in 2006–07.
New Zealand Fisheries Assessment Report 2011/51.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

Hartill, B.; Vaughan, M.; Rush, N. (2011). Recreational harvest estimates for SNA 8 in 2006–07.

New Zealand Fisheries Assessment Report 2011/51.

The aerial overflight method has recently been used to provide plausible estimates of the recreational harvest for some fisheries in QMA 1. A pilot survey of the recreational fishery in SNA 8 was undertaken during the summer of 2005–06, to determine whether this approach could be used to estimate the recreational harvest from this stock. The four key findings of the pilot survey were: 1) that although the aerial overflight method could not be used to directly assess the harvest taken by dispersed and cryptic surf casters and longliners, the likely scale of this harvest did not warrant a targeted survey; 2) aerial counts and creel survey data suggested that the majority of the harvest was taken from trailer boats and that it was still reasonable to account for the shore based harvest in the same indirect manner as that used in QMA 1; 3) the diurnal pattern of fishing effort was similar to that observed in QMA 1; and, 4) there was evidence to suggest that the harvest from charter boats was potentially substantial and that this could easily be assessed using a voluntary logbook scheme given the limited number of vessels involved in the fishery.

A formal assessment of the overall recreational harvest from SNA 8 was conducted during the 2006–07 fishing year. The recreational fishery was broken down into three mutually exclusive components: the private boat fishery, the shore based fishery, and the charter boat fishery. The aerial overflight method was used to assess the harvest from private boats. This method appears to be well suited to this purpose, as trailer boats accounted for a very high proportion of the vessels that were observed from the air to be fishing. Further, there are relatively few boat ramps on the west coast, which increases the probability that these vessels will return to a limited number of surveyed ramps. The harvest of snapper from this sector of the fishing community was estimated to be 162.7 t.

Data collected during the pilot survey suggested that 8.5 % of the recreational harvest in SNA 8 was taken from the shore. This figure is very similar to an estimate of 8.4 % obtained from the most recent telephone diary survey in 2001. When these data are used to scale up the aerial overflight estimate given above, the snapper harvest tonnage estimate increases to 178.9 t.

Enquiries identified 18 charter boats that operated in SNA 8 in 2006–07, and of these, 15 provided a full 12 months of logbook data. Imputation of data thought to describe the remaining three vessels resulted in a total harvest estimate of 79.5 t for this fleet. A further seven vessels have been since identified mostly on the Kapiti Coast, all with assumed minor catches in the context of the total fishery. These operators have been asked to estimate the weight of snapper they caught over the survey period, which has raised our estimate to 81.6 t.

Combining the estimates from these three fishery components we estimate that the overall recreational harvest from SNA 8 in 2006–07 was 260.5 t (with 95% confidence intervals of 222.0 and 307.1).

1. INTRODUCTION

At the inception of the quota management system there was no information on recreational harvest[1] levels other than anecdotal reports. Since then, there has been an increasing recognition of the need to quantify recreational harvests, particularly for stock assessment purposes and to assist in the increasingly controversial process of allocating the Total Allowable Catch between fishing sectors. A recreational harvest estimate for SNA 8 in 1990 was among the very first recreational harvest estimates available. That estimate was derived in an incidental and ad hoc manner, from a tagging programme conducted primarily to provide a biomass estimate. A recent examination of tag returns from the 1990 programme strongly suggests that many commercial fishers returning tags claimed to be recreational fishers, to collect a reward but to avoid providing information that could lead to a reduction of the SNA 8 TACC (Hartill et al. 2008).

The first dedicated attempts to quantify recreational harvest were telephone/diary surveys, which also provided estimates for the SNA 8 fishery. These surveys were initially regional (1991–92, 1992–93 and 1993–94 (Teirney et al. 1997)) and then national, in 1996 (Bradford 1998), 2000 and 2001 (Boyd et al. 2004). Survey designs became increasingly sophisticated as shortcomings with previous studies became apparent, and in June 2004 a Recreational Technical Working Group concluded that harvest estimates from the diary surveys should be used with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries. A major limitation of those surveys was the indirect manner in which the data were obtained, and this led to a shift towards a more observational approach.

The most reliable and cost effective means of directly estimating the recreational harvest from a large scale trailer-boat rod and reel fishery that is currently available is the aerial overflight approach, which has recently been developed and applied in QMA 1 (Hartill et al. 2007a, 2007b). Before applying this methodology to another fishery, however, an understanding of the nature and extent of all sources of recreational harvest from this fishery is required. Most recreational fisheries research has been conducted on the east coast of the North Island, and the information available on the SNA 8 recreational fishery was limited. A pilot survey was therefore conducted in 2005–06, to test a series of assumptions before designing and implementing a full scale survey to estimate the recreational harvest taken from SNA 8 during the 2006–07 fishing year.

This report documents the findings of the pilot survey conducted in the summer of 2005–06 and the design and results of a full scale formal assessment of the recreational harvest from SNA 8 in 2006–07.

2. METHODS AND RESULTS

2.1 Pilot survey

2.1.1 Relative significance of the shore based harvest of snapper

In SNA 8, recreational fishers use a diverse range of methods to harvest snapper, both shore based and vessel based. Shore based fishing effort is too dispersed and cryptic to reliably assess using the aerial overflight approach. Because of this, it was necessary to assess the relative significance of the shore based fishery to determine whether it warranted direct assessment, and if so, how to adapt the existing methodology to assess this harvest.

The only information already available on the overall nature and extent of the west coast recreational fishery, prior to this programme, was that derived from telephone diary surveys conducted intermittently

[1] Harvest is defined here as the fish that are captured and retained by a fisher (includes those captured and used for bait, but not those fish that are released).

since 1992. Although the magnitudes of the harvest estimates derived from these surveys are thought to be unreliable, diarist data can be used in a relative sense to shed some light on the nature of this fishery. Cursory examination of recent diarist harvest and effort data suggested that vessel based harvests in 2000 and 2001 accounted for 83.6% and 91.6% of the total recreational harvest, respectively (Figure 1). Although these proportions are large, there is appreciable interannual variation in these estimates. This may be partially attributable to the low numbers of diarists who fished in SNA 8 in the 2000 and 2001 surveys; 150 and 246 diarists, and 418 and 617 trips respectively.

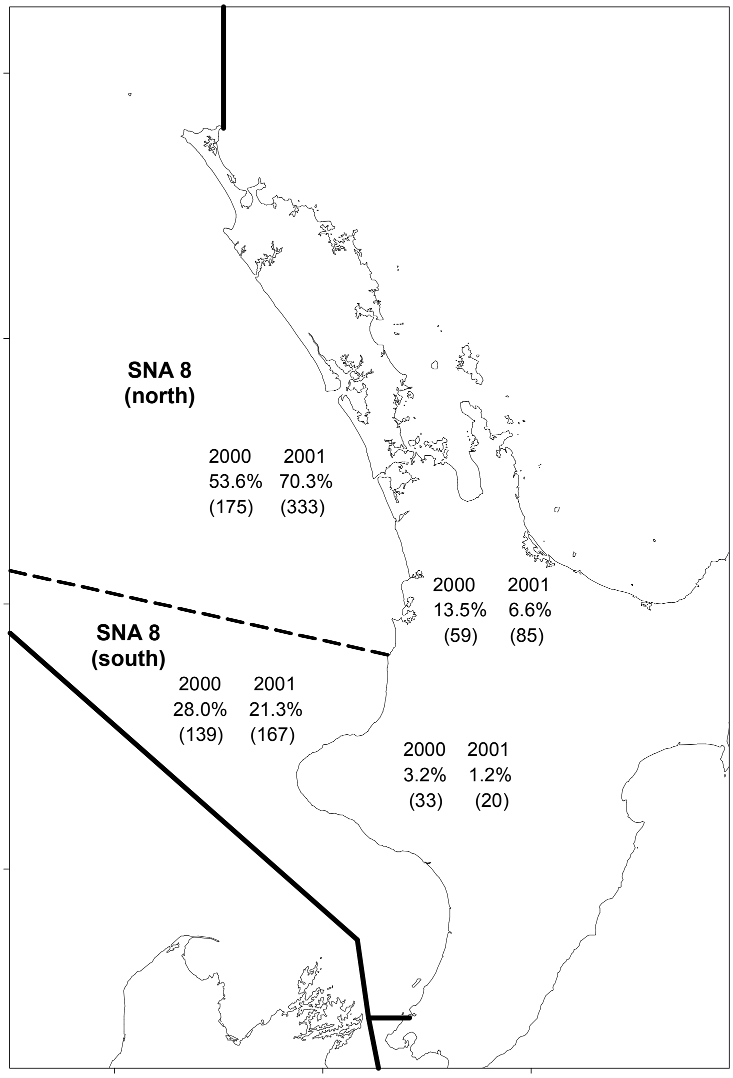


Figure 1: The percentage of the number of snapper caught from boats, and from the shore, by area, as reported by diarists in the 2000 and 2001 telephone/diary surveys. Tables plotted over open water give survey specific percentages of the number of snapper caught by diarist from boats in both surveys, and those plotted over the North Island are for the harvest taken by shore based methods such as surfcasting and kite fishing. Percentages do not include the 1–2% of fish caught by minor methods such as diving and set netting. The number of reported trips associated with harvest percentages are given in brackets. These estimates have no demographic weighting.

The variability of these estimates and the potential magnitude of the shore based harvest warranted a more direct comparison of the shore and boat based fisheries. We used two sources of observational data to estimate the magnitude of the shore based harvest relative to that which is taken from recreational vessels. These sources of information were aerial counts of shore and vessel borne fishers, and interview data collected from both types of fishers returning to selected access points. Both forms of data were collected in a broadly concurrent fashion, on 10 randomly selected weekend days between 1 October 2005 and 30 April 2006. Only weekend and public holiday days were considered, as the chances of observing appreciable levels of fishing effort, and thus determining the relative influence of shore based harvests, was highest on these days. In some instances, survey days were rescheduled, due to strong onshore winds, which would have suppressed all forms of fishing effort. Wind direction and strength strongly influence a fisher's tendency to go fishing, especially kite fishers, who require reasonable offshore winds. Some kites can be flown in winds of only 5 knots, but most require at least 10 knots to get sufficient lift (Paul Barnes, fishing kite retailer, pers. comm.). On most survey days, only light winds were experienced, although surveying took place on two days with 15–20 knot winds, one day with offshore winds and one with onshore winds (Table 1). The predominance of these wind patterns reflects the neutral to El Nino climate experienced at the time (J. Salinger, Principal Climate Scientist, NIWA, pers. comm.).

Table 1: Numbers of days with different combinations of wind speed and wind direction, as recorded at Auckland International Airport. The top panel gives the number of days these conditions occurred over the period 1 October 2005 and 30 April 2006, and the second panel gives counts for survey days only.

	Wind	Wind speed (knots)					Total
Day type	direction	0 to <5	5 to <10	10 to <15	15 to <20	20+	days
Weekends /Public holidays	alongshore	14	16	9	1	2	42
	offshore	6	8	2	2	–	18
	onshore	2	4	5	5	1	17
		22	28	16	8	3	77
Midweek days	alongshore	19	23	9	1	1	53
	offshore	22	9	3	1	–	35
	onshore	6	13	13	11	4	47
		47	45	25	13	5	135
Total		69	73	41	21	8	212

	Wind	Wind speed (knots)					Total
Day type	direction	0 to <5	5 to <10	10 to <15	15 to <20	20+	days
Survey days	alongshore	2	1	–	–	–	3
	offshore	2	1	–	1	–	4
	onshore	0	1	1	1	–	3
Total		4	3	1	2	–	10

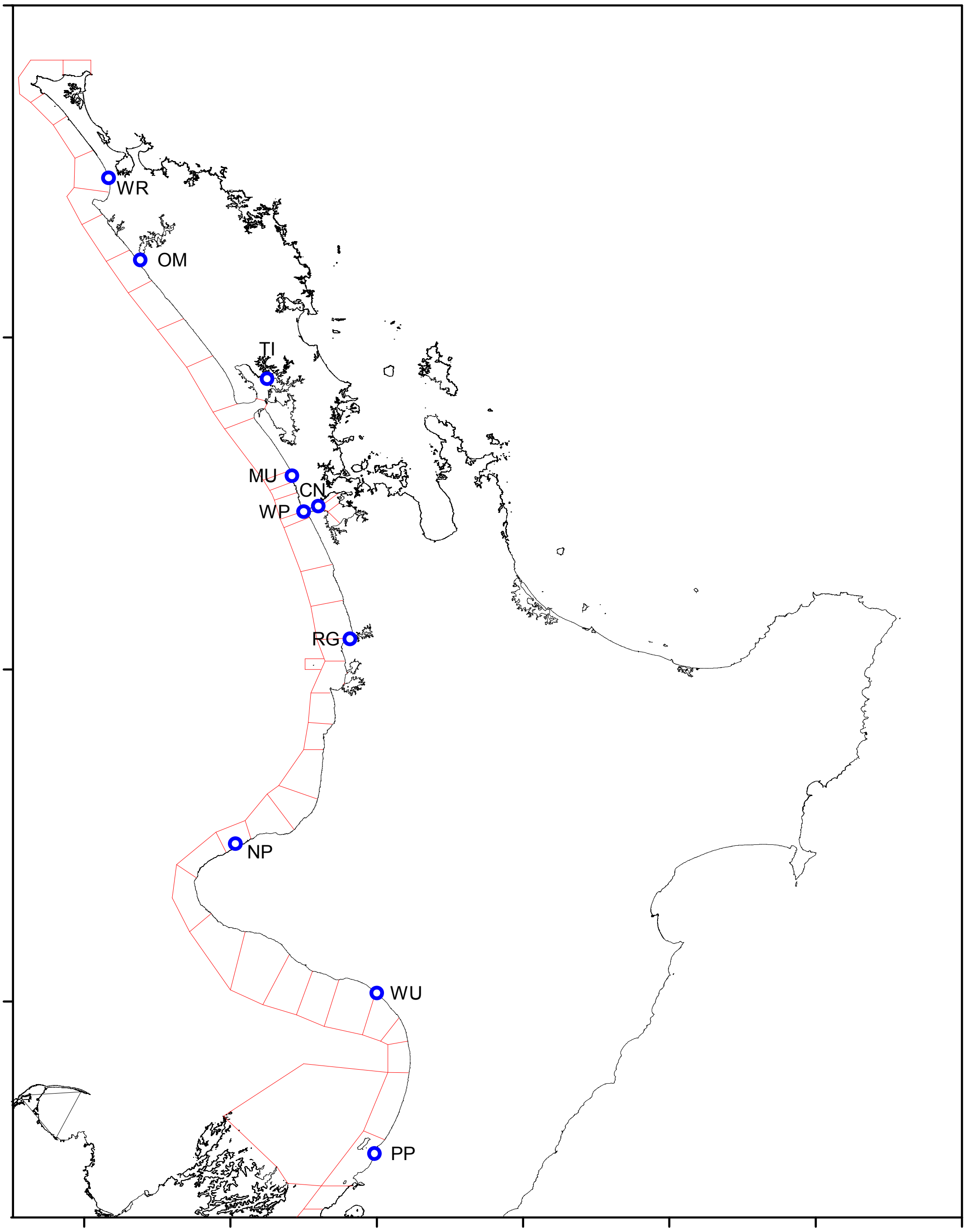
The entire SNA 8 coastline (excluding the Three Kings Islands) was flown four times a day, on all but one survey day. The rationale for multiple flights is discussed in section 2.1.2, but data from all four flights are combined here on a daily basis, where they are used to compare relative numbers of shore and boat based fishers. Three standard routes were flown: from South Kaipara Head to the eastern side of Spirits Bay, from Port Waikato to South Kaipara Head (including the Kaipara and Manukau Harbours), and from Port Waikato to Titahi Bay on the Wellington (Porirua) coast. Single engine Cessna 172s (110 knot airspeed) were used for the two northern flights, and a faster (180 knots) twin engine Piper Aerostar was used to cover the more extensive southern route. Counts were made on both outward and inward legs (two legs on two flights giving counts at four times of the day).

Each plane flew at approximately 500 feet, either along or inland of the coastline, so that the observer could count both shore based fishers, and vessels fishing within sight of land. Excursions were also made off harbour mouths, but offshore fishing grounds such as in the south and north Taranaki Bights were not surveyed, which could lead to an underestimate of the boat based harvest. Separate counts were made of: (a) fishing vessel types (catagorised as either trailer boats, yachts, launches, charter boats or kayaks) which were later converted to fisher counts based on average boat type occupancy data available from an on-the-water survey conducted in 2003–04 (Hartill et al. 2007a), (b) hard and soft shore surfcasters, (c) kite fishers, (d) electric kontiki fishers and (e) "others". Almost all of the observed vessels were trailer boats, and only stationary boats involved in fishing were counted.

Aerial observers used standard laminated maps of the shoreline and strata to record counts, and noted the time at which their plane passed from one area to another (Figure 2). Pilots acted as secondary observers, counting all boats on their side of the plane. This necessitated clear communication between the two parties, as to who was counting which boats in which areas, with overall responsibility resting with the primary observer. Route navigation was left to the pilot, although intervention by the observer was sometimes necessary when they felt that the area was not being covered to their satisfaction, or when the pilot was not affording the observer the best possible view of the majority of the boats. Only a limited pool of pilots was used, and they soon became very proficient at optimising the routes flown, and spotting vessels. The days, times and routes flown by each observer were selected randomly to minimise any observer bias.

Counts of boat based fishers, surfcasters and shore based longliners are given in Figure 3. These counts are based on only eight of the ten survey days flown, as a malfunctioning plane necessitated the cancellation of northern flights on one afternoon, and one of the days coincided with the 90 Mile Beach Lion Red Snapper Classic fishing competition, which was considered highly atypical, as the number of surf casters observed on this competition day greatly exceeded that seen on any other day.

Two thirds of the fishers observed along the west coast fished from boats. Surfcasters were observed more often than trailer boat fishers on the open coast between Port Waikato and Cape Reinga (Figure 3). In the North, trailer boat fishing was more predominant in harbours, especially when onshore swells made other forms of fishing difficult. On days with calmer weather, some vessels move from the harbour to fish on the open coast, but many vessels stay in sheltered waters. Low numbers of shore based longlines were observed throughout SNA 8, and we suspect that battery powered kontiki fishing is responsible for a larger proportion of the harvest than kite fishing, as deployment is less weather dependent and can, therefore, take place on many more days. Fishing kites were clearly visible from the air, but most of the kites observed were flying at a very low altitude, very close to the shore, and the wind on these days may have often provided insufficient lift to carry a line offshore. Battery powered kontikis are hard to spot from the air, although the orientation of vehicles and people on the beach often results in closer scrutiny of such groups. In some areas, a high proportion of the surfcasters were associated with river mouths, where catches of snapper are unlikely. Shore based fishers are also less visible than fishing boats, and some may, therefore, have been missed.



CN	Cornwallis	RG	Raglan
MU	Muriwai	TI	Tinopai
NP	New Plymouth	WP	Whatipu
OM	Omapere	WR	Waipapakauri
PP	Paraparaumu	WU	Wanganui

Figure 2: Location of access points where fishers were interviewed and spatial sampling strata used in the pilot survey of SNA 8 in 2005–06.

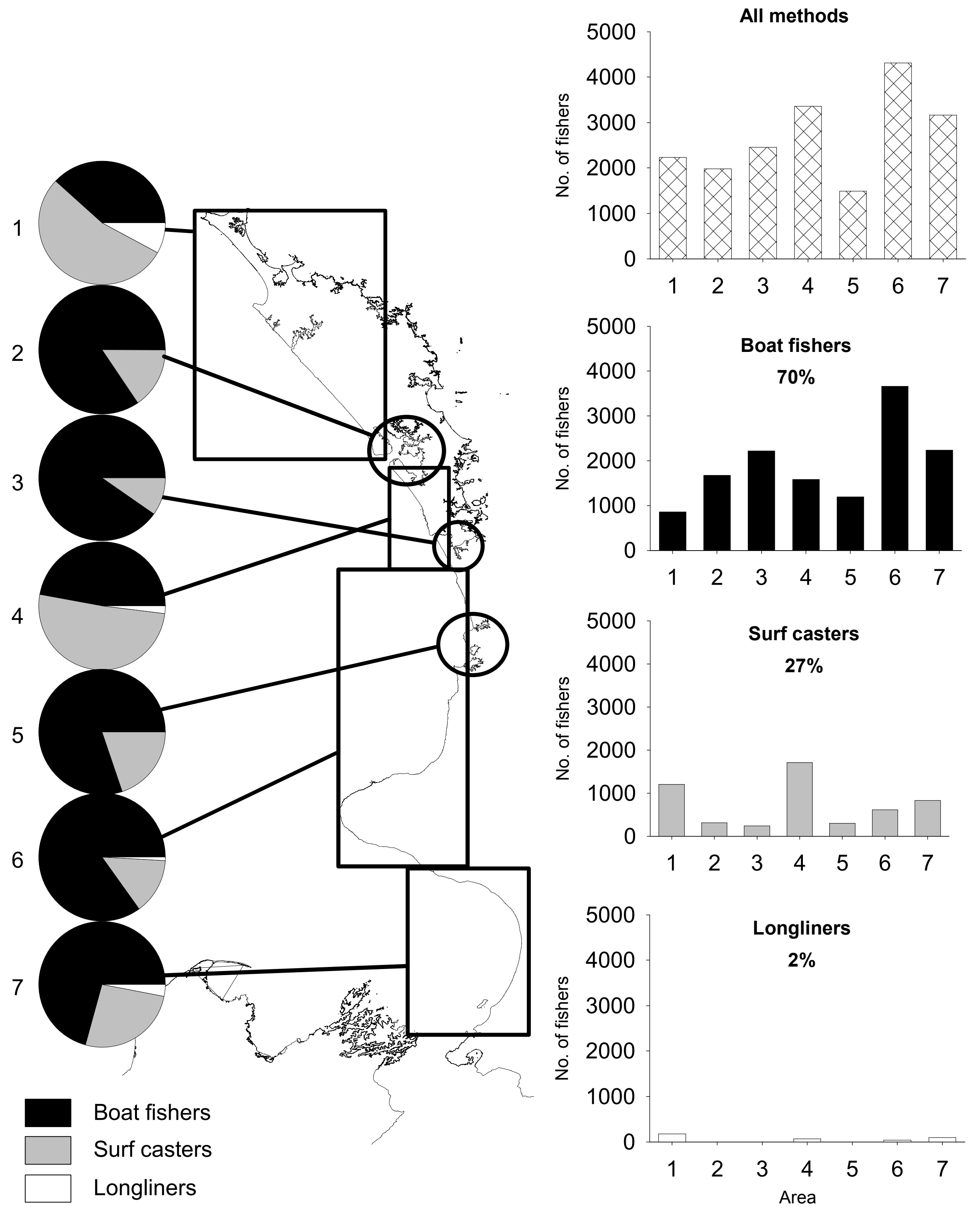


Figure 3: Total numbers of boat based fishers, surf casters and shore based longliners observed by aerial observers during eight weekend survey days in 2005–06. Four survey flights were made each day to allow for both diurnal and tidal influences on relative fishing effort. Counts from smaller scale survey strata have been combined to give results for four open coast areas, and three harbour areas.

Although these aerial based observations give us some insight into the relative intensity of shore and vessel based fishing effort, access point interviews were also required to provide data on harvest composition, harvest rates and trip durations. Interviews were conducted at eleven locations between Waipapakauri, on Ninety Mile Beach, and Paraparaumu, on the Kapiti coast in the south (Figure 2). The access points selected represent a range of situations, including those associated with boat fishing in harbours (Omapere, Cornwallis and Tinopai) and with open coast surfcasting from beaches (Waipapakauri, Muriwai, and Whatipu).

Almost all interviewing took place on the same day that flights took place, although on a couple of days one or more flight was cancelled due to low cloud. When a flight was postponed at the last minute, interviews were still conducted. Concurrent collection of aerial counts of fishers and access point interviews is not essential, however, as they are not combined to provide daily harvest estimates in the pilot study. Access points were staffed over a twelve hour period, ending at around dusk so that returning fishers could be approached over a full tidal cycle (Table 2).

Table 2: Summary of interviewing effort, numbers of fishing parties and individuals interviewed, by fishing method and access point.

				Fishers						
				Boat			Shore			
Ramp	Days	Hours surveyed	Parties interviewed	Rod	Longline	Trolling	Rod	Longline	Other	Total
Waipapakauri	11	120	46	1	1	–	31	6	10	49
Omapere	10	145	63	142	–	14	–	–	7	163
Tinopai	10	133	110	264	–	–	10	–	16	290
Muriwai	11	146	155	2	–	–	230	22	27	281
Whatipu	10	123	163	5	–	–	285	–	24	314
Cornwallis	10	123	186	393	2	24	–	–	129	548
Raglan	10	121	162	436	8	34	–	–	29	507
New Plymouth	10	118	366	759	64	185	–	–	52	1 060
Wanganui	9	116	142	388	52	36	–	2	8	486
Paraparaumu	10	127	187	406	10	32	2	–	135	585
		1 270	1 580	2 796	137	325	558	30	437	4 283

Interviews of recreational fishers followed the format of those undertaken in all previous boat ramp surveys conducted by the Ministry of Fisheries and NIWA, ensuring that data were collected in a consistent and previously tested manner. Data collected during these interviews can be used to determine where fishing took place, at what time, which methods were used, and which fish were caught by each fisher, for any given combination of method, area and time. In most cases the interviewer was able to measure the harvest, but when this was not possible, a count or estimate of the number of fish of each species was made and the nature of that count recorded. From these data it is possible to estimate average catch rates (or harvest rates when fish were landed) in terms of the number of fish, and the weight of fish (via length weight relationships).

Some extra, opportunistic sampling also occurred at Waipapakauri in relation to the Twilight Tournament, which is a surfcasting competition held by fishing clubs on 90 Mile Beach. These data are not discussed further, as they are considered atypical, but it is worth noting that only 49 of the 239 participating fishers caught a total of 88 snapper between them, and that the heaviest snapper caught was 4.19 kg. Other participants did not report any landings of snapper. The largest competition in this area is the 90 Mile Beach Lion Red Snapper Classic, which is a team competition with several rules which limit the snapper harvest. A team, of two to four people, can only land up to four snapper a day, which must all be longer than 30 cm. The only prizes are for the heaviest fish per day (five days) and for the competition, so it is likely that many of the snapper which were caught were thrown back. Approximately 800 to 850 fishers land 200 to 300 snapper each year (Tony Brljevich, competition organiser, pers. comm.).

There are marked differences in the species composition of catches landed by fishers using differing methods in different areas of SNA 8 (Figure 4). Interviewers encountered 80 species, most of which were only occasionally landed, and some of which were shellfish. The most commonly encountered finfish species were snapper, kahawai, gurnard and blue cod. Snapper is the species most commonly caught by boat fishers in the north on the open coast and in harbours. In the south blue cod were most commonly caught by boat fishers. On the west coast, species other than snapper make up a greater proportion of the vessel based harvest than in SNA 1 (Hartill et al. 2007b). The species composition of shore based longliners appears to be similar to that of their boat based counterparts, at least in the north, where most longline fishers were encountered. Most interviews of surfcasters took place on the open coast in the north, and by far the most commonly caught species was kahawai, followed by yellow eyed mullet, trevally, and then snapper. Some divers and set netters were also interviewed, who mainly landed shellfish, butterfish, and yellow eyed mullet.

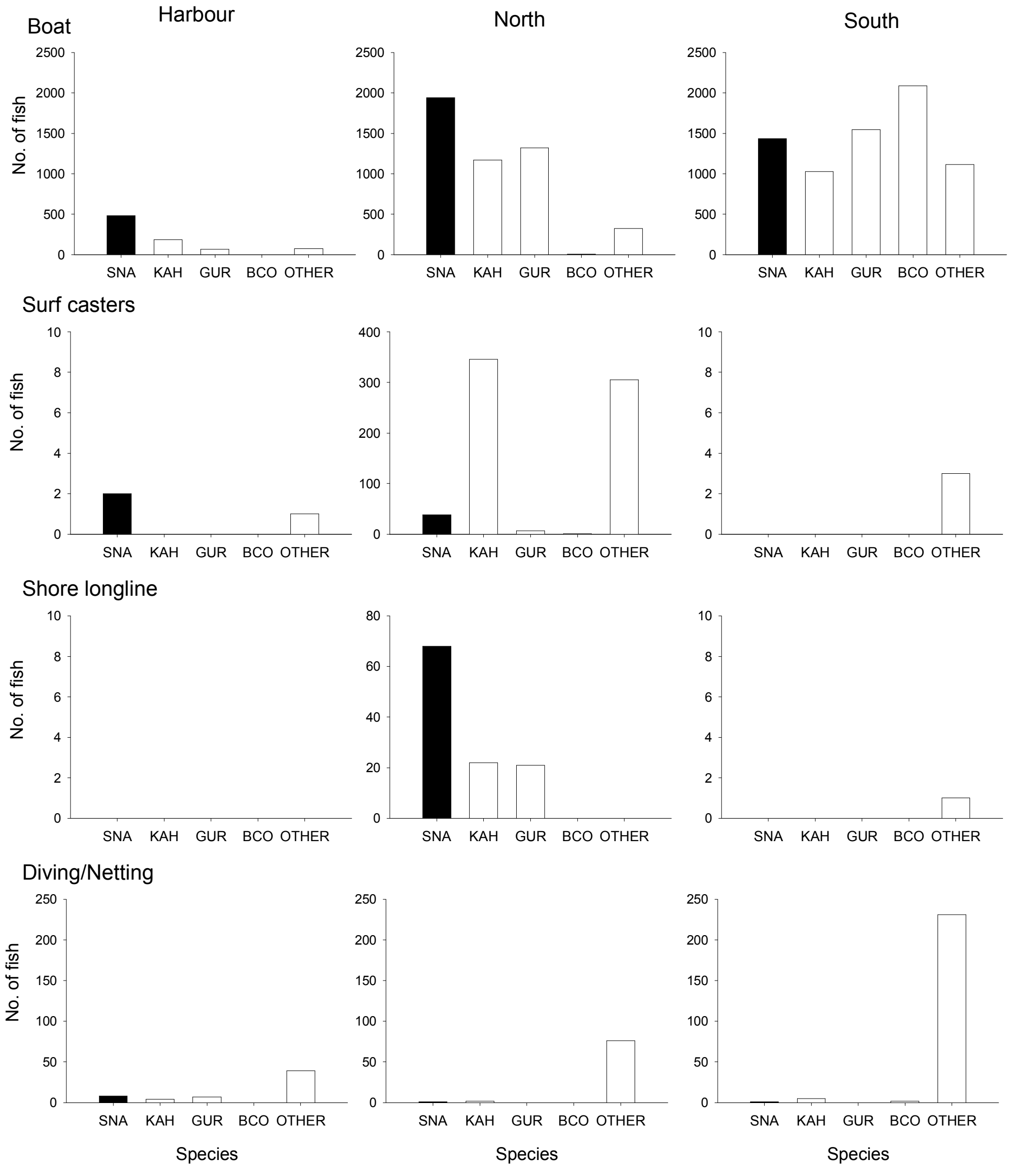


Figure 4: Species composition of harvest by area and fishing method. Harbour harvest is fish caught in the Hokianga, Kaipara, Manukau and Raglan Harbours; Northern harvest is fish caught north of Kawhia Harbour, and Southern harvest is fish caught south of Raglan Harbour.

Snapper bag sizes (numbers landed per fisher) also differ by area and method (Figure 5). There are two types of fishers that frequently caught several harvestable snapper in a trip, those fishing from boats and those deploying longlines from the shore. The most successful boat based fishers are those who fish on the open northern coast, over half of whom land snapper, averaging more than two snapper per trip. Harbour fishing is less productive, although over 40% of those fishing from boats who were interviewed during the pilot survey landed snapper. In the south, only 28% of those fishing from boats landed snapper, but more than five fish are caught on some of these trips. The most successful fishers, in terms of the number of snapper caught, were those deploying longlines from the shore, in the north. Over half of these fishers were successful, landing an average of 2.43 snapper per trip (including zero harvest trips). Only a small proportion of the interviewed surfcasters, divers, and set netters landed snapper.

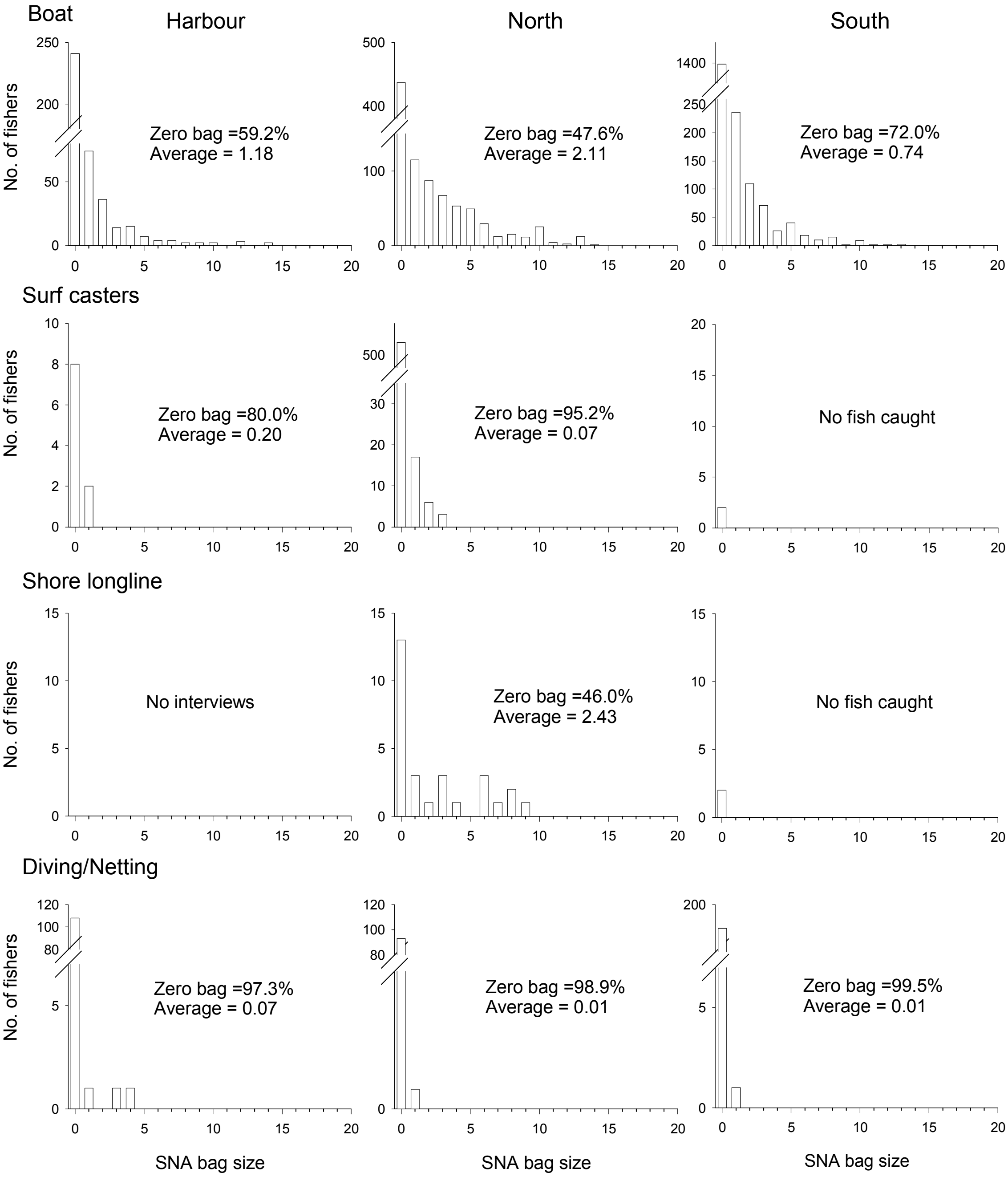


Figure 5: Frequency of numbers of snapper landed per trip by area and fishing method (see caption of Figure 4 for area definitions).

Almost all of the snapper that were measured by interviewers were caught from boats, and consequently, these length frequencies are the best described (Figure 6). Most of the snapper caught in the harbours were less than 35 cm in length, whereas a far greater size range is caught on the open coast, both in the north and in the south. Although the length composition of the shore based longline harvest is poorly described, there is evidence to suggest that the average size of snapper caught by this method is much larger than that caught by other methods.

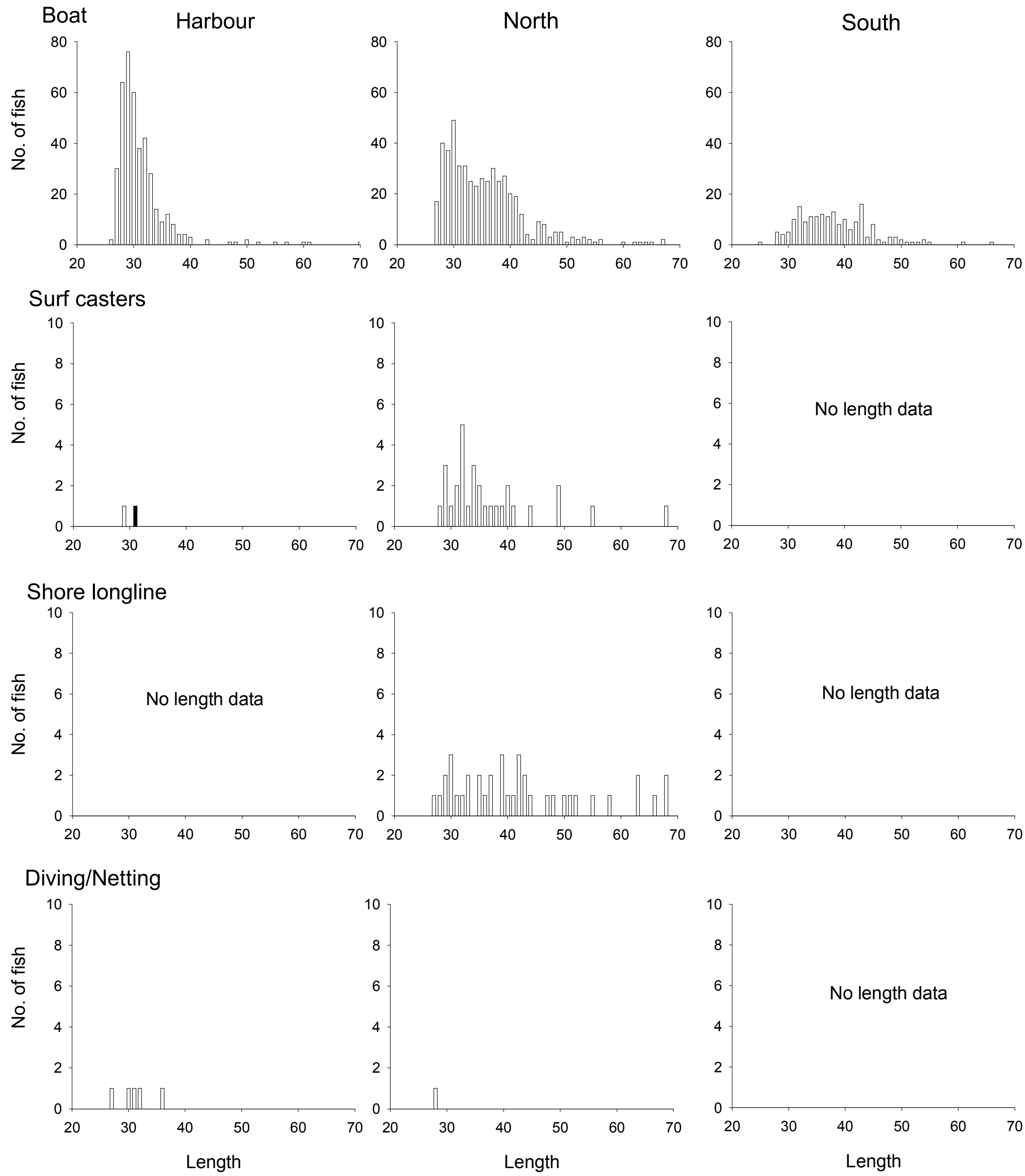


Figure 6: Length frequency distributions of snapper landed by area and fishing method (see caption of Figure 4 for area definitions).

The relative significance of the shore based harvest in each area can be inferred by combining average daily aerial counts of each type of fisher, with associated estimates of the average weight of snapper landed by each type of fisher (Table 3). The average weight of snapper caught by a type of fisher is initially calculated by combining the average number of snapper caught per fishing trip (see Figure 5) with an estimate of the average weight of snapper caught (derived from the length frequency data given in Figure 6). When these trip harvest weights are applied to the respective average daily counts of each type of fisher (Figure 2, with areas collapsed into "North", "South" and "Harbour") the results are similar to those derived from telephone/diary data (see Figure 1) with 91% of the harvest taken from boats (compared to previous estimates of 81.6% in 2000 and 91.6% in 2001).

Table 3: Relative harvest of snapper by fishing method group, by area.

Average fisher bag of snapper

Area	Boat fishers	Shore longlines	Surfcasters
Harbour	1.18	–	0.20
North	2.11	2.43	0.07
South	0.74	0	–

Average snapper weight (g)

Area	Boat fishers	Shore longlines	Surfcasters
Harbour	713	–	598
North	1 053	1 886	1 198
South	1 345	0	–

Average fisher catch weight (g)

Area	Boat fishers	Shore longlines	Surfcasters
Harbour	843	–	120
North	2 226	4581	83
South	999	0	–

Average number of fishers counted from the air per survey day

Area	Boat fishers	Shore longlines	Surfcasters	All fishers
Harbour	636	0	105	741
North	305	30	364	699
South	737	17	180	934
SNA 8	1 678	48	649	2 375

Average daily catch weight (kg)

Area	Boat fishers	Shore longlines	Surfcasters	All fishers
Harbour	536	0	13	549
North	679	139	30	848
South	736	0	??	736
SNA 8	1 951	139	43	2 133

Relative catch

Area	Boat fishers	Shore longlines	Surfcasters	All fishers
Harbour	25%	0%	1%	26%
North	32%	6%	1%	40%
South	35%	0%	??	35%
SNA 8	91%	6%	2%	100%

In this survey, no snapper were observed by southern boat ramp interviewers during the relatively few interviews obtained with shore based fishers. Consequently, the harvest by this sector of the fishery was estimated as zero, which is unlikely to have been the case in practice. Some shore based fishers will have landed snapper. Regardless, it is unlikely that the shore based harvest of snapper in the south would have been significant in the overall context of the SNA 8 recreational fishery. This is because shore based fishers only accounted for a small proportion of the total fishing effort seen in aerial surveys in the south (Figure 2), because the incidence of snapper landings by shore based fishers is on average generally low (Figure 4), and because snapper are generally less dominant in southern landings (also Figure 4).

The overall results of the pilot survey given in Table 3 suggested that although a substantial proportion of fishers on the west coast of the North Island are surfcasters, the method only accounted for a very small proportion of the total snapper harvest (2%). Thus, further direct assessment of the harvest by these fishers was not warranted given the difficulty and cost associated with surveying them. Shore based longliners appeared to account for a greater, though still comparatively small (6%), proportion of the snapper harvest.

As the combined shore based harvest was relatively low (in the order of 10% of the overall recreational harvest in SNA 8) and difficult to assess in a cost effective manner, we recommend that all forms of shore based fishing should be assessed indirectly, using telephone diary data, in a similar manner to that used in assessments of the QMA 1 fisheries (Hartill et al. 2007a and 2007b).

2.1.2 Diurnal distribution of fishing effort

Our knowledge of the west coast fishery was limited, especially with regard to the extent to which the tide influences fisher behaviour. As part of our pilot survey design, therefore, we flew at four times of the day, to determine whether all types of fishing effort peaked at mid day, in the generally consistent and predictable manner observed in QMA 1 (Hartill et al. 2007a, 2007b). Ideally, these flights should have been allocated random flight times within each of four set time periods, but the extent of the survey area flown meant that there was little flexibility for randomisation (which would be a serious shortcoming if we were to apply the traditional diurnally stratified aerial overflight approach described in Pollock et al. 1993).

Flight counts of boat based fishers, surfcasters and shore based longliners are given in Figure 7, for four times of day, for each of the 10 days flown (counts have been combined from the three flight routes). In most cases, fishing effort peaked late in the morning, or occasionally early in the afternoon. Similar trends are evident for surfcasters and boat based fishers. Close examination of these data suggests that the timing of high tides has a limited influence on the intensity of fishing effort observed.

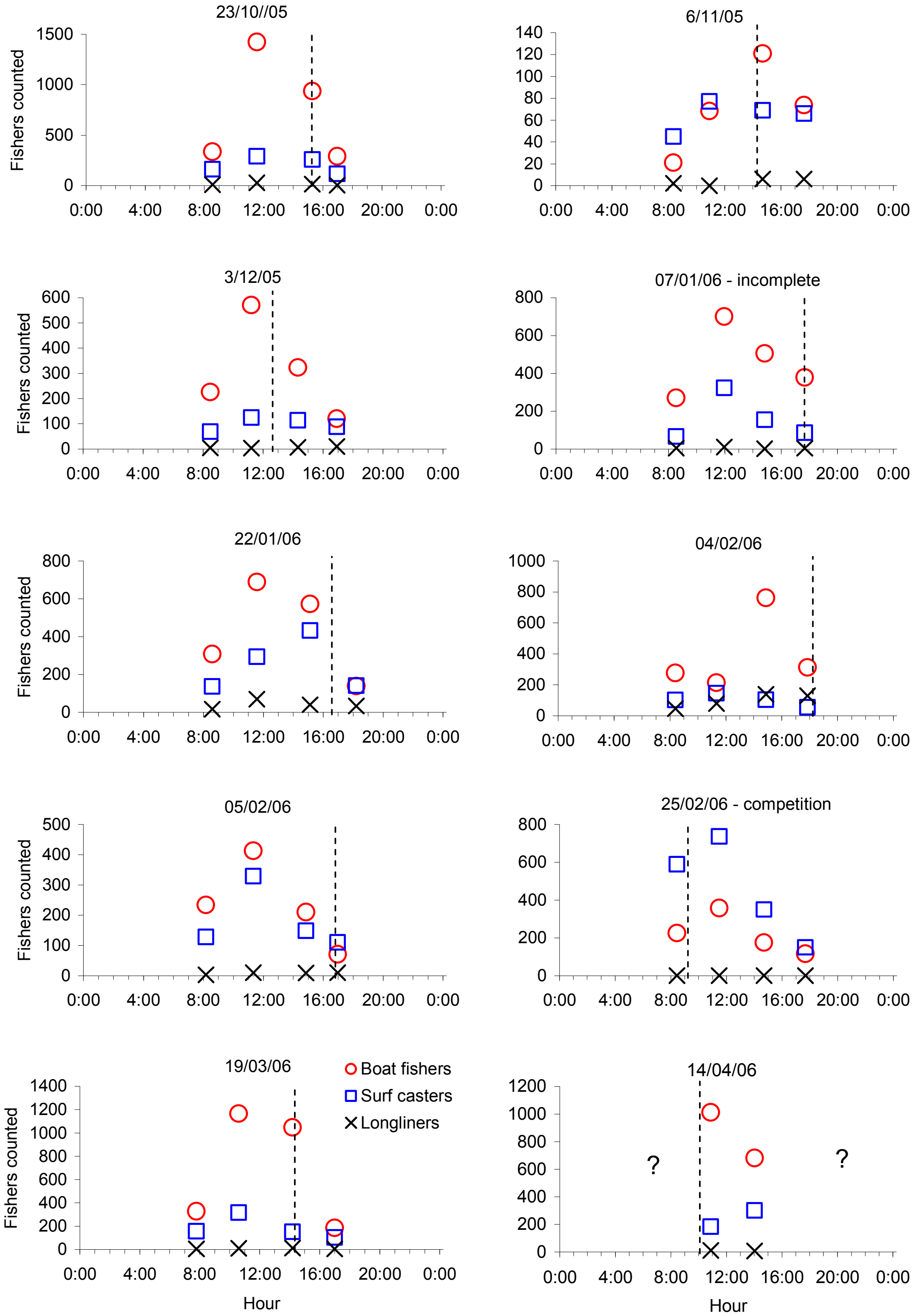


Figure 7: Counts of three types of recreational fishers made by aerial observers flying over SNA 8 at four times of the day, for each of 10 survey days. Results for the 25/02/06 may be atypical, as they include counts of surfcasters participating in the 90 Mile Beach Lion Red Snapper Classic competition. Only two flights were made on the 14/04/06 due to a shortage of daylight hours. The northern flight on 07/01/06 was cancelled because of an aircraft malfunction. Vertical dashed lines denote the time of high tides occurring during daylight hours.

2.1.3 Conclusions drawn from the pilot survey

The following observations were taken into account when designing the formal survey of the recreational SNA 8 fishery in 2006–07:

- That it is difficult to reliably estimate the number of shore based fishers from the air as they are not always readily visible and sightings of people on the beach are subject to misinterpretation, especially in poor weather.
- That the shore based harvest of snapper by rod and reel accounts for less than 2% of the total harvest, which does not warrant explicit estimation.
- That the shore based longline (kite and electric kontiki) harvest was estimated to be about 6% of the total harvest, and given the relatively low incidence of this method and difficulties with accessing these fishers at the end of their trips, direct estimation of their harvest is not feasible.
- That the diurnal pattern of fishing effort on the west coast generally displays a similar mid day peak to that seen on the east coast. From this we concluded that only a single mid day aerial survey of the extent of SNA 8 would be required to enumerate the number of fishing vessels on each survey day.
- That the recreational fishery on the west coast of the North Island is very diverse, with different species and size compositions landed along the open coast and in the large northern harbours. Careful attention should, therefore, be made to ensure that any selection of spatial strata reflects this diversity in catch composition and fishing success.
- Aerial observations and enquiries led to the conclusion that a significant proportion of the harvest from SNA 8 was potentially taken from charter boats, and a dedicated log book survey was warranted for this fishery.

2.2 Estimating the SNA 8 harvest in 2006–07

2.2.1 Defining fisheries to be surveyed

A marine recreational fishery, such as that in SNA 8, is in fact a complex mix of fisheries, with fishers using a wide variety of methods across a range of habitats to access the resource(s). Three key method groups were identified which were separately assessed, either directly or indirectly: shore based fishers, fishers using charter boats, and those fishing from private vessels. All harvests were estimated for the period of 1 October 2006 to 30 September 2007, which coincided with the 2006–07 SNA 8 fishing year. The methods used to estimate the harvest from the three method groupings are discussed in turn.

2.2.2 Estimating the shore based harvest

From the pilot survey we concluded that the shore based harvest of snapper, by both surf casters and longline fishers, accounted for about 8.5% of the harvest from SNA 8. This figure is similar to that derived from the 2001 telephone diary programme of 9.1% (246 diarists made 617 trips over the year assessed), but a higher estimate of 16.4% is available from the 2000 telephone diary survey (150 diarists made 418 trips) (Boyd et al. 2004).

The harvest by these fishers did not, therefore, warrant the logistically complex and costly survey approach which would be required to estimate the tonnage landed by shore based fishers. Some cursory calculations based on the pilot survey suggested that the total SNA 8 harvest was likely to be in the order of 200 to 300 tonnes, in which case the shore based harvest would be less than 30 tonnes (assuming 10% of the total harvest). Even if we assumed that the shore based harvest was as high as 20% of the total harvest, this still did not justify a formal assessment.

Because a formal survey of the SNA 8 shore based harvest was not justified, an indirect means was used to estimate this harvest component. The approach taken was the same as that used in similar recent surveys; whereby diarist data on shore based harvests relative to boat based harvests is used to rescale an aerial overflight estimate of the private boat based harvest (discussed in section 2.2.4). This was done by using diarist data collected in the 2001 telephone diary survey. The reason why the data associated with a 9.1% estimate obtained indirectly in 2001 was used in preference to the 8.5% estimate obtained from the more recent and observational pilot survey, was because the diarist data were amenable to bootstrapping, and could thus be incorporated into an accepted variance estimation procedure. Regardless, there is little difference between diary and survey based estimates of the percentage of the harvest attributable to shore based fishers, especially given the uncertainty which is associated with this component of the overall SNA 8 harvest estimate.

2.2.3 Estimating the harvest from charter boats

In SNA 8 the open coast is less hospitable than on the east coast due to the lack of sheltering offshore islands, exposure to the prevailing westerly winds, and also because most vessels have to navigate a harbour bar to access the open waters off the west coast. Charter boats are run by experienced operators (many of whom are ex-commercial fishers) and offer a safer and relatively productive means of targeting the resource. Aerial observations and enquiries suggested that a potentially significant proportion of the SNA 8 recreational harvest was taken from charter vessels. A voluntary logbook programme was used to obtain a harvest estimate from this sector of the fishery. Enquiries identified 17 businesses that operated 18 vessels in the SNA 8 fishery at the beginning of the 2006–07 fishing year. These vessels were based between the Kaipara and Wanganui. In addition, two vessels operating out of the Hokianga, one from Dargaville and four from the western Wellington region have been identified since then. These vessels were not covered by our programme but are considered later.

Operators were asked to fill out daily trip logs on which they recorded the date, the number of fishers on a trip, the number of snapper they retained, and an estimated weight for those snapper. The logbooks were designed to be as undemanding as possible to maximise cooperation rates, as this was a voluntary survey. Operators were contacted every couple of months and asked to send in records for the previous period as soon as possible. Most operators were willing participants and provided many useful insights into how the fishery operated in their area. Petrol vouchers were given to the operators at the end of the survey, with a letter outlining the results of their logbook and the combined estimated harvest weight landed by the surveyed charter fleet.

Of the 18 vessels that were identified and actually fished in 2006–07, 15 provided data for the full fishing year. The annual estimated weight of snapper reported by vessel skippers ranged from 0.13 to 15.5 tonnes. Harvest tonnages for the three vessels that did not provide any data were approximated by asking local cooperating skippers to identify vessels that would be most similar to the non-responding ones. The most similar vessel harvest tonnages ranged from 1.7 to 5.5 t. The total harvest tonnage was estimated based on the reported data for 15 vessels and imputed values from most similar vessels for the three non-responding operators.

The reported harvest estimate from the combined charter boat fleet of 18 vessels was 79.5 tonnes. Examination of daily records by individual operators suggests that some reported atypically high average weights (Figure 8). Peaks are clearly evident with trip based average fish weights of 1, 2, 3 and 4 kilograms, which suggests that many operators estimated the weight by multiplying a fish count by an estimate of the average fish weight, rather than simply estimating the weight of the entire grouped harvest. Many of these operators are ex-commercial fishers who have experience in both targeting large fish and estimating aggregate fish weights. Nonetheless, the potential for overestimating fish weights exists, especially as many patrons will retain their harvest separately in private chilly bins, leading to aggregate estimation error. The number of fish landed can be regarded with greater confidence, however, as less subjective judgement is required when reporting this metric.

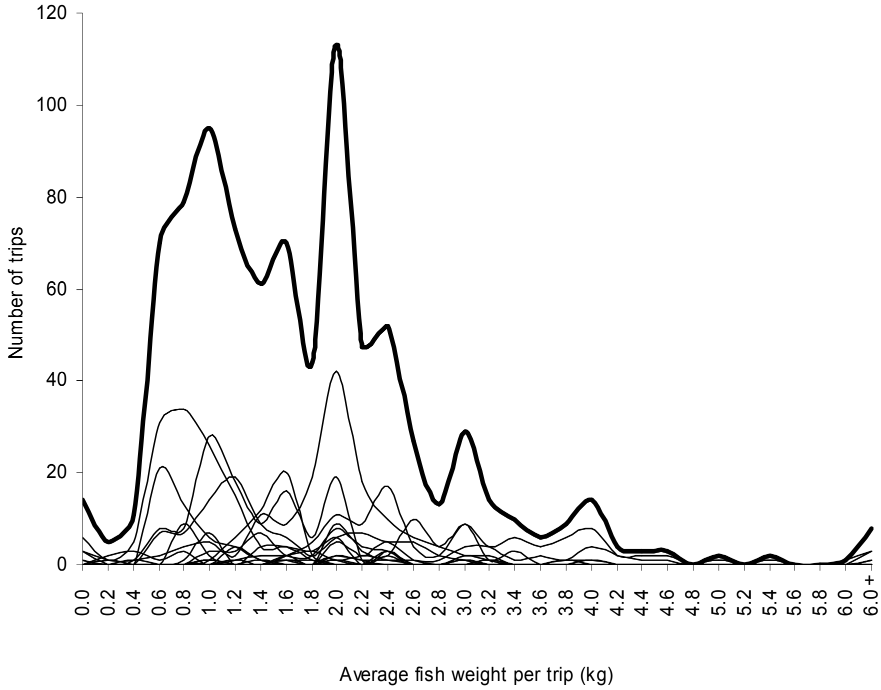


Figure 8: Distribution of trip based average fish weights reported by charter boat operators. The bold line denotes the frequencies for the entire fleet and the finer lines denote frequencies by vessel. Values were calculated by dividing the estimated weight of snapper caught on a trip by the associated reported total number of snapper landed from that trip. The corresponding average weight of all snapper measured during boat ramp surveys was 1.014 kilograms.

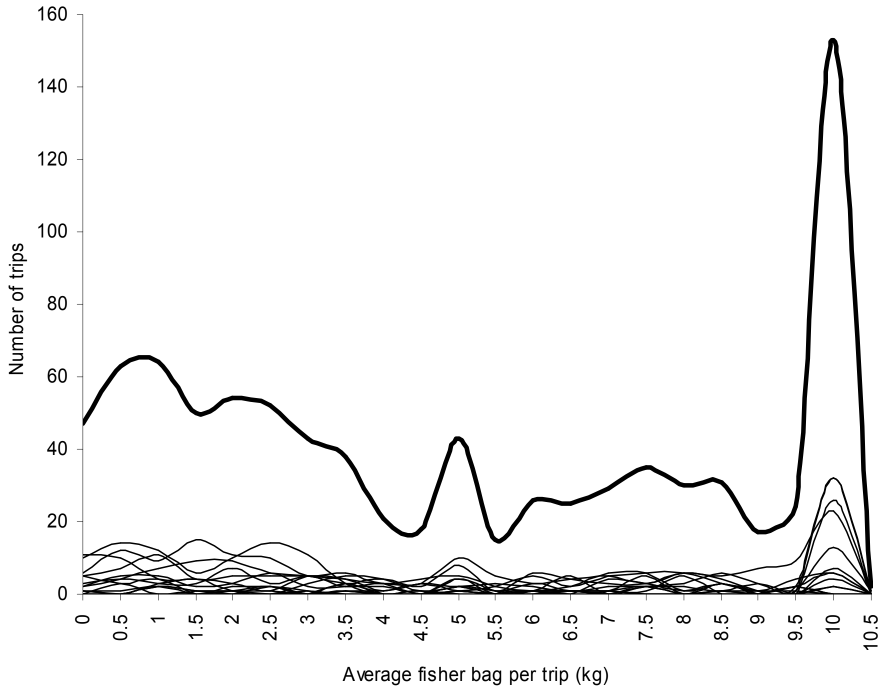


Figure 9: Distribution of average fisher bags per trip (expressed in terms of average estimated harvest weight). The bold line denotes the frequencies for the entire fleet and the finer lines denote frequencies by vessel. Values were calculated by dividing the reported number of snapper landed from a trip by the number of participating fishers.

If the average fisher bag per trip is estimated by dividing the reported number of snapper landed from a trip by the number of participating fishers, it suggests than many, but not all, fishers caught their legal bag limit of 10 fish (Figure 9). Of the 880 reported trips, there were 155 for which the average fisher bag was 10 fish, but these are averaged across the trip, and it is likely that a far higher proportion of fishers would have achieved their bag limit.

An alternative and conservative estimate of the charter boat harvest is to multiply the number of fish landed from a vessel by an average fish weight estimate derived from boat ramp data in the neighbouring area. Boat ramp interviewers measured landed snapper, and these measurements were converted to individual fish weights (via a length weight relationship, Paul 1976) and averaged. When this approach is taken, the 2006–07 harvest estimate for the 18 surveyed charter vessels drops from 79.5 tonnes to 39.1 tonnes.

Once again, this is likely to be conservative estimate, as most operators are probably more capable of targeting larger fish than the average fisher returning to a boat ramp. For this reason, the 79.5 tonne estimate will be used hereon, although this is probably an overestimate. Concern was expressed by some operators about the possibility of quotas being introduced for charter boats. This may have led to the temptation to report inflated catches to create a catch history, which could then be used as a basis for a future quota tonnage allocation. Although we assume misreporting for this purpose did not occur, the possibility remains.

Further allowance is required for the Hokianga Harbour (2), Dargaville (1), and Kapiti Coast operators (4) who have since been identified. These fishers were asked to estimate the total annual snapper harvest landed from their vessels from SNA 8. The reports combine to an additional 2.1 tonnes to be added to our charter boat harvest estimate, raising it to 81.6 t. The Ministry of Fisheries is currently evaluating the feasibility of a compulsory charter boat logbook scheme, which should reduce uncertainty surrounding the number of operators participating in a fishery and the harvest landed from these vessels.

When the 81.6 t logbook estimate is combined with other forms of recreational harvest (see section 2.2.3) the charter boat fleet accounts for 31.3% of the total non-commercial harvest in 2006–07 (or alternatively 17.9% when fish counts are combined with mean fish weight estimates to give the conservative estimate of 39.1 t). This estimate of the fraction of the SNA 8 fishery taken from charter boats is far higher than that obtained from diarist data in the 2000 (4.8%) and 2001 (7.4%) telephone diary surveys. It is unlikely that this difference reflects a change in the relative importance of the charter boat fleet over the intervening five years given the magnitude of the change over a six year period and the length of time that many of these vessels have been operating. The logbook estimate is derived in a far more direct manner, a near census of the whole fleet, and is more likely to be accurate.

There are at least three reasons why the diarist estimate of the charter boat based fraction may be low. Firstly, and perhaps primarily, is the fact that diarist recruitment programmes tend to attract avid fishers, and intermittent fishers are less likely to participate in a survey on recreational fishing. Avid fishers are more likely to own a boat, from which they fish, hence enhancing the apparent relative importance of this source of harvest. Charter boat operations, in contrast, are more likely to attract less frequent fishers, who are less likely to have their own boat. Also, charter trips are often a form of social interaction for groups of co-workers etc. These fishers may still have reasonable success as their fishing is guided by an expert. Their charter boat harvest would likely be poorly described by a diarist based programme, however, as they participate infrequently.

Secondly, tourists from overseas are more likely to go fishing from a charter boat than a private boat, but these fishers would never be identified in a national telephone diary survey. Thirdly, diarists fishing from charter boats may have mistakenly claimed to have fished from a private boat, although this is unlikely to be common.

2.2.4 Estimating the harvest from private vessels

The method used to assess the harvest from private vessels in SNA 8 was essentially the same as the aerial overflight approach used to survey recreational fisheries in the Hauraki Gulf in 2003–04 (Hartill et al. 2007a), in QMA 1 in 2004–05 (Hartill et al. 2007b) and in QMA 7 in 2005–06 (Davey et al. 2008). Daily harvest estimates, collected according to a randomised, temporally stratified design, were weighted together to give either seasonal or annual harvest estimates.

An estimate of the harvest on each survey day was obtained by using an instantaneous count of the number of boats fishing at a set time of day to scale up an observed harvest, given the number of interviewed parties who claimed to be fishing at the time of the overflight. The aerial count should, preferably coincide with the time of peak fishing effort, as it is used to determine the overall level of effort on the day, and should, therefore, be based on an observation of as great a proportion of the effort as possible, especially on low effort days.

This method is, therefore, loosely based on that described by Pollock et al. (1993), which has been used to assess the Lake Taupo trout fishery since the mid 1980s (Department of Conservation 1991) and the western Hauraki Gulf snapper fishery in 1994 (T. Sylvester, MAF Fisheries, unpublished results). Those studies used flights at several times of the day to provide estimates of fishing effort and harvest at different periods of the day, whereas we use counts from a single overflight which are used to scale up data collected from boat ramp interviews conducted throughout the day. The pilot survey demonstrated that multiple flights per day covering the entire west coast of the North Island were neither logistically feasible for a more intensive sampling programme, nor were they cost effective. Relative levels of fishing effort, harvest, and harvest rates can still be inferred for other times of the day, by integrating boat ramp interview data collected throughout the day, and then scaling these on the basis of the instantaneous count taken at approximately mid day.

The analytical approach used is discussed throughout the next sections, to provide a framework for the survey results. A succinct description of the analytical approach is given in Appendix 1 of Hartill et al. (2007a), which includes mathematical formulae.

2.2.4.1 Temporal stratification

All aspects of the survey followed the same temporal (and spatial) survey design. The temporal definitions used to stratify sampling effort are to some extent nominal, being two seasonal strata (summer, 1 October 2006 to 30 April 2007; and winter, 1 May 2007 to 30 September 2007) and two day-type strata (week days and weekends/holidays). A start date of 1 October was considered desirable, as it coincided with the fishing year, and the likely onset of the summer fishery in late October/early November.

Practically no information was available on daily levels of fishing effort in SNA 8 throughout the year, and we were therefore unable to determine the optimal level of sampling effort which should be allocated to each temporal strata, or indeed, overall. We adopted the expedient of basing our design upon that used in the previous QMA 1 survey (Table 4). In doing this we assumed that the tendency of fishers to go fishing through the year followed a similar pattern to that on the east coast, with potentially higher levels of effort (and hence variability in an absolute sense) occurring during the summer, when catch rates are higher, daylight hours peak, and weather conditions are generally more favourable for recreational fishing. Most sampling effort was therefore allocated to this seasonal stratum. Fishing effort is generally higher during weekends and public holidays (Hartill et al. 2007a, 2007b)

As with the QMA 1 survey, a total of 45 sample days were allocated across the four temporal strata. A lower level of sampling effort was considered to reduce costs, but observations made during the pilot survey suggested that fishing effort in SNA 8 was less predictable than in QMA 1, as the fishery is more weather dependent.

Table 4: Sample design for aerial-access survey for the summer (1 October 2006 to 30 April 2007) and winter (1 May to 30 September 2007) seasons.

Season	Temporal strata	No. of days in strata	Days flown	Sampling intensity
Summer	Midweek days	117	10	0.085
	Weekends/holidays	66	19	0.288
Winter	Midweek days	127	8	0.063
	Weekends/holidays	55	8	0.145

2.2.4.2 Spatial stratification

As with the pilot survey, three planes were required to cover the coastal extent of SNA 8 in as brief an interval as possible; two single engined Cessna 172s covering waters to the north of Port Waikato, and a faster, twin engined Piper Aerostar, which was used to assess the southern half of the fishery. Surveying took place on the outward leg of the flight, followed by a direct return flight back to Ardmore aerodrome.

Although instantaneous counts provide unbiased estimates of fishing effort (Pierce & Bindman 1994), the time taken to census any of the three flight routes would have necessitated a progressive count methodology which has inherent biases that are difficult to overcome reliably (Hoenig et al. 1993). We therefore spatially stratified each of the flight routes into smaller areas which are readily defined by local landmarks apparent from 500 ft. These areas were closely based on those used in the pilot survey (Figure 3). Areas associated with the two main harbour mouths were further divided at the point where the harbour entrance opened out into open waters for this survey (Figure 10). Counts of vessels within each area were treated as instantaneous counts, as the time taken for an aircraft to traverse this area is many times less than vessels would take to cover the same distance.

These spatial strata were used in all aspects of this programme, although contiguous strata were aggregated into larger analytical areas for analysis. This is necessary because very little fishing occurs in some areas, and the amount of information available to describe levels of fishing effort and harvest rates is considered too limited to derive sensibly precise harvest estimates over smaller spatial scales. The rationale for combining broadly similar spatial strata into analytical areas was the catch characteristics derived from data collected during boat ramp interviews (as given in section 2.2.4.5). Another determinant of break points between analytical areas was the location of stretches of coastline on which very little fishing effort was observed.

2.2.4.3 Aerial overflights – estimating instantaneous fishing effort

The methods used by the aerial observers and the manner in which they recorded their counts broadly followed those used in the pilot survey (see section 2.1.1). On this survey's flights, however, no attempt was made to detect and count shore based fishers, as these are accounted for indirectly in this survey, and any attempt to do so would have distracted the observers from their primary purpose: to enumerate vessel based fishing.

On each randomly predetermined survey day survey flights of two and a half to three hours duration were conducted, weather permitting, starting at approximately 0930. This corresponded to the time of peak fishing activity seen in the pilot survey data. Flights followed roughly the same route each time, based upon the need to cover the survey area as efficiently as possible.

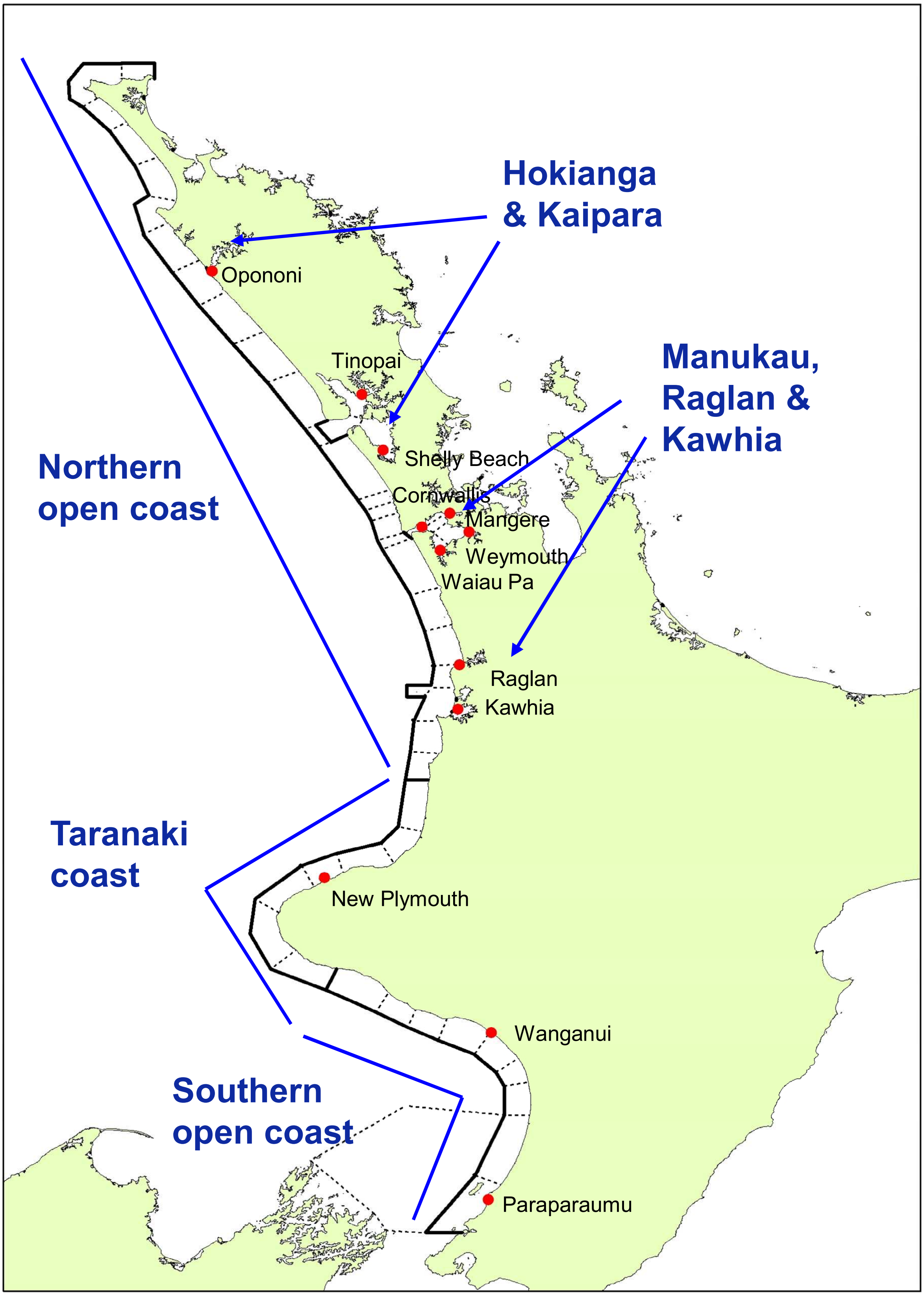


Figure 10: Location of access points where fishers were interviewed and the spatial strata used in the aerial overflight survey of SNA 8 in 2006–07. Dashed lines denote area definitions used by aerial observers and during boat ramp interviews. Solid offshore lines denote groups of areas for which harvest areas were calculated in the final analysis of the data.

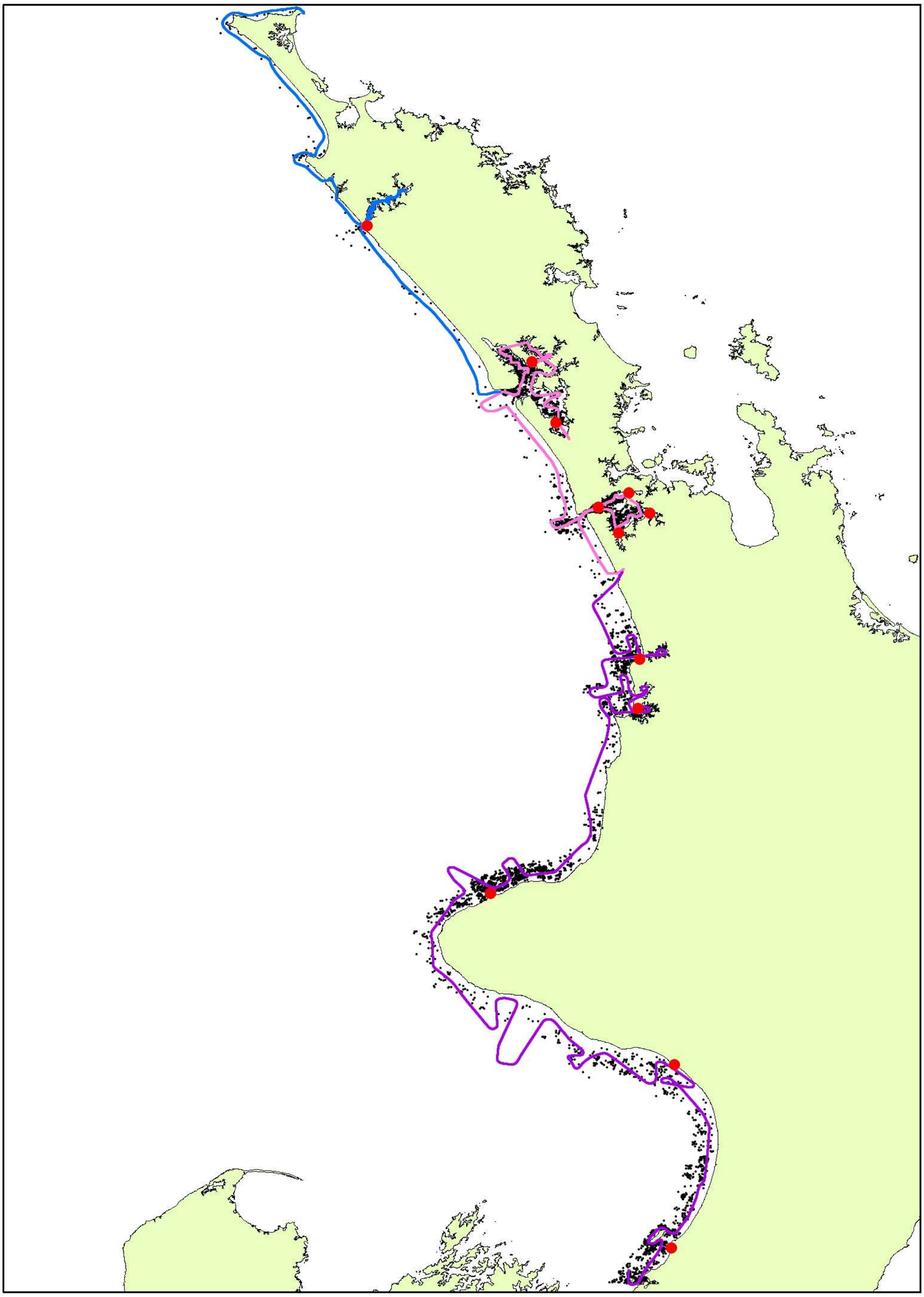


Figure 11: Typical flight routes followed during the overflight survey (solid lines). Dots over water denote the positions of boats recorded by aerial observers on all flights combined.

Most of the flight path was within one kilometre of the coastline, but with some notable exceptions (Figure 11). Wide loops were flown off harbour entrances, towns and around offshore islands, where fishing is known to occur. The southern flight also routinely passed through a series of waypoints off the South Taranaki Bight, which were based on features which the Wanganui coastguard thought were commonly fished.

Although some flying took place offshore, the possibility remains that some of the fishing effort associated with snapper landings was not observed from the air, because offshore fishing may have occurred in areas where surveying occurred close to the shore. This possibility can be explored as interviewed fishers were asked to estimate how far offshore they had fished (Figure 12). These estimates suggest that the majority of fishers fished within a few kilometres of the shore.

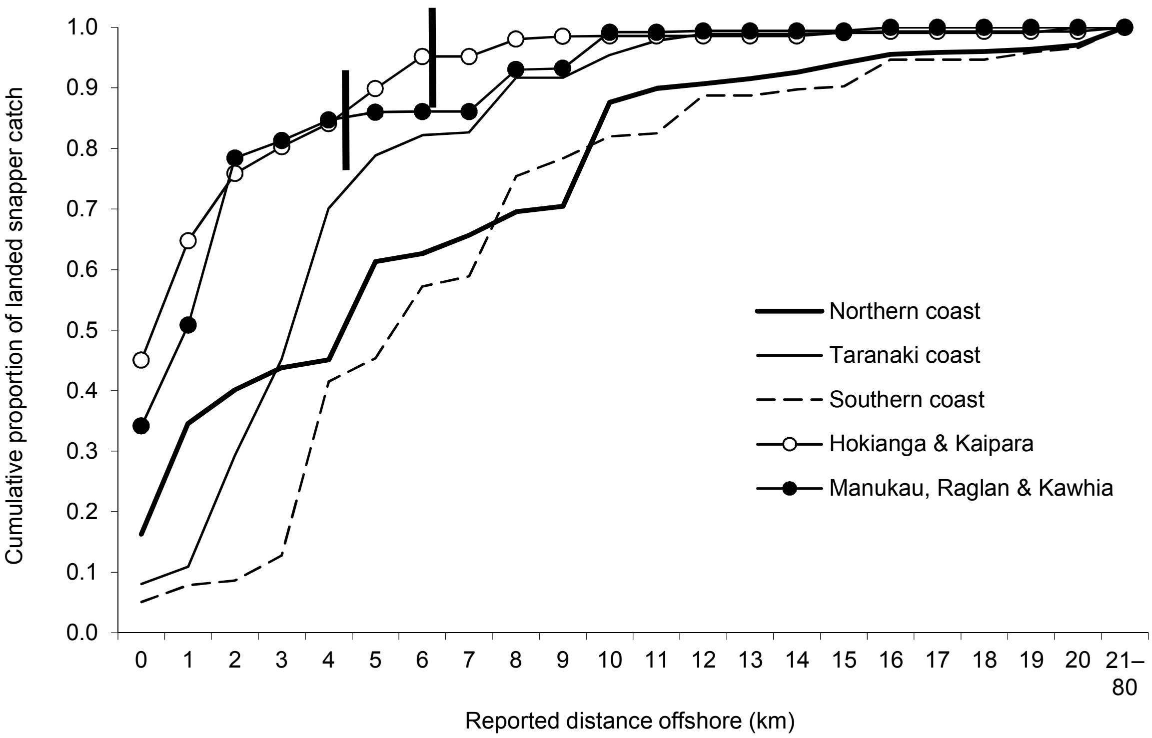


Figure 12: Cumulative proportion of harvested snapper as a function of the reported distance from shore, by analytical area. The vertical bars associated with the harbour data sets denote the greatest distance that it is possible to fish from the shore in these harbours.

The distance that fishers claimed to have fished offshore can be compared with estimates of the distance that planes flew offshore in each area (calculated from the flight paths given in Figure 11). On the open coast, planes flew at an altitude of between 500 and 1000 feet. At this height, fishing vessels should be clearly visible at a distance of three kilometres.

When fisher estimates of the distance they fished offshore are compared with an estimate of the distance the plane flew offshore in each area (buffered by a further visual range of three kilometres) it appears that a small percentage of boats catching snapper may have been missed in some areas. All vessels in harbours were potentially within visual range of the observer. On the open coast, however, approximately 10% of the reported harvest in the North may have been taken more than three kilometres seaward of the area covered by observers, compared to 1% for the Taranaki area and 6% for the southern coast. Fisher estimates of the distance they fished offshore are likely to be unreliable (unless radar or GPS technology is intentionally used) and are possibly overestimates as described below. Overestimation is clearly seen in estimates reported by harbour based fishers in Figure 12. Between 10 to 15 % of interviewed fishers in these harbours claim to have been fishing further from the shore than the maximum possible in these enclosed waters. It is likely that estimates provided by offshore fishers have similar issues with accuracy. One fishing party claimed to have fished 80 km offshore, which is not considered credible. Nonetheless, a small percentage of the snapper harvest may have been overlooked during the survey.

Almost all of the actively fishing recreational vessels counted by aerial observers were classified as trailer boats, regardless of the area, or day type flown (Table 5). This marked dominance of trailer boats suggests that the aerial overflight approach is a very appropriate means of assessing the harvest from private vessels in SNA 8, as almost all of these vessels would have returned to boat ramps, many of which we sampled as part of the companion boat ramp interview survey. The only area in which launches commonly accounted for more that 10% of the vessels seen was in the Kaipara Harbour. It is likely that many of these vessels were in fact commercial set netting vessels (from which small dinghies and dories are operated), or charter boats, as these are commonly seen on the harbour and can be easily mistaken for a private launch by inexperienced observers. If this misclassification has occurred, it would lead to an overestimation of the harvest.

Table 5: Percentage of vessel types observed during midday flights of the five analytical areas, by season and day type. The counts of charter boats given here are not used in the aerial overflight harvest estimate, as the harvest from these vessels was estimated via a logbook survey instead.

Analytical	Boat	Summer		Winter	
Area	type	Weekend	Midweek	Weekend	Midweek
Northern	Trailer boat	92.6	95.8	95.8	84.2
Open	Launch	3.2	2.1	1.3	10.5
Coast	Chart boat	3.2	2.1	3.0	5.3
	Yacht	–	–	–	–
	Kayak	1.0	–	–	–
Taranaki	Trailer boat	98.8	100.0	97.3	92.6
Open	Launch	0.4	–	2.7	3.7
Coast	Chart boat	0.1	–	–	3.7
	Yacht	0.1	–	–	–
	Kayak	0.5	–	–	–
Southern	Trailer boat	96.9	90.2	95.2	89.7
Open	Launch	1.7	7.3	2.9	6.9
Coast	Chart boat	0.5	2.4	1.0	3.4
	Yacht	0.6	–	1.0	–
	Kayak	0.3	–	–	–
Hokianga	Trailer boat	89.4	80.3	88.5	81.7
and Kaipara	Launch	6.8	14.8	6.5	15.0
Harbours	Chart boat	3.1	3.3	4.3	3.3
	Yacht	0.3	1.6	0.7	–
	Kayak	0.4	–	–	–
Manukau,	Trailer boat	97.1	100.0	98.6	98.6
Raglan and	Launch	0.5	–	1.0	1.4
Kawhia	Chart boat	0.2	–	–	–
Harbours	Yacht	0.4	–	0.5	–
	Kayak	1.8	–	–	–

For the small percentage of boats that were not trailer boats (and hence would not potentially be encountered by boat ramp interviewers) it was necessary to transform counts of these boat types into trailer boat counts, to account for differing levels of boat occupancy on these vessels. The data used for this transformation of launch, yacht, and kayak counts were those collected during an on the water survey of boat type occupancy as part of a series of eight daily on-the-water surveys conducted in the Hauraki Gulf in 2003–04 (Hartill et al. 2007a). These results suggested that average occupancy rates were: trailer boats, 2.5 fishers; launches, 2.9 fishers; yachts, 2.6 fishers; and kayaks, 1.6 fishers. All launch counts, for example, were multiplied by 2.9/2.5, to account for the higher occupancy of this vessel type relative to that encountered in trailer boats returning to ramps. In doing this we assumed that vessel type had no influence on either catch rates or fishing durations.

Consistent patterns were evident in the spatial and temporal distribution of fishing vessels counted by aerial observers. Fishing effort was predictably generally highest in the summer months, and, within a season, far higher on weekends and public holidays (Figure 13). The number of vessels typically observed in each of the analytical areas was broadly similar, although trends through time differed. Effort in the north and in the harbours was steady within a season, but in Taranaki the number of boats seen increased markedly after Christmas, and in the South it increased substantially in mid March. As with all aerial surveys conducted nationally to date, most fishing effort appears to take place in sheltered waters close to population centres. Fishing effort was highly variable from day to day within any temporal/spatial stratum, clearly in response to local weather conditions.

Low cloud prevented a full aerial survey of the west coast on some of the preselected survey days. Low cloud was most commonly encountered on the open coast south of Kawhia, and flights by the aircraft flying this route were often either cancelled outright, or terminated part way through, when conditions became marginal.

Estimates of the number of boats fishing at midday are required for all survey days. However cancellations were weather dependent, and not random. Therefore estimates of the number of boats that would have been counted from the air on these days were based on the relationship between aerial counts and numbers of boats reported fishing at the time of the overflight, which returned to surveyed ramps on those days (Figure 14). Regressions based on boat ramp data suggest that fishing activity was generally low on all the days on which flights were cancelled.

Rescheduling cancelled flights to a previously unselected day was not considered advisable, as this would have biased our random selection of sample days towards days with more fishable conditions, leading to a positively biased harvest estimate.

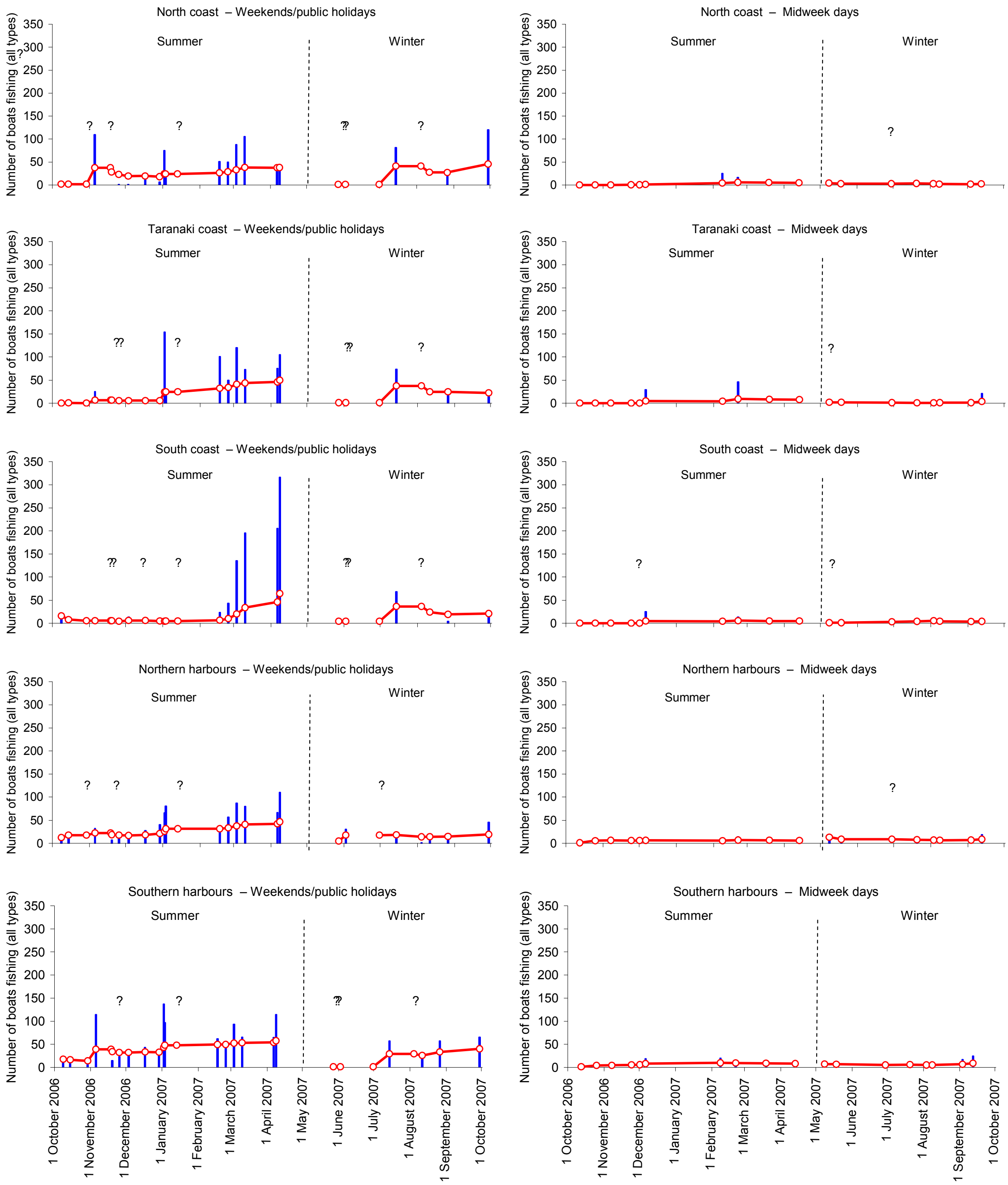


Figure 13: Counts of recreational fishing boats (all types combined) made by airborne observers on late morning flights during weekends/public holidays (left panel) and midweek days (right panel), by analytical area. Running averages are given as continuous lines for each season, which are recalculated on each successive survey day (denoted by closed circles). Question marks denote days on which low cloud prevented aerial counts of recreational fishing vessels.

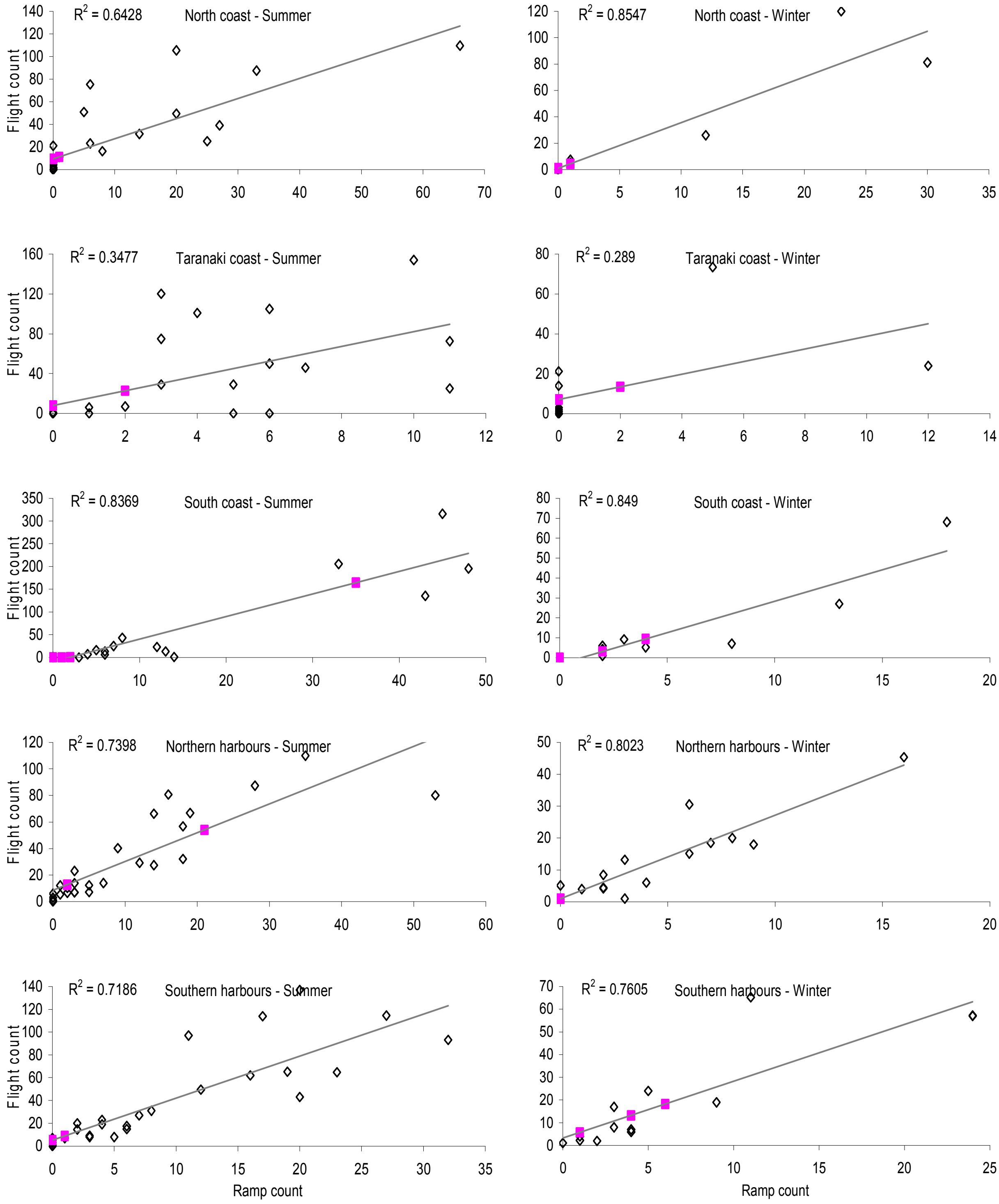


Figure 14: Season/area specific relationships between daily counts of the number of boats observed from the air and the number estimated from boat ramp data at the time at which the flight took place (open diamonds). These relationships were used to predict the number of vessels that would have been counted on those days when flights were cancelled due to weather conditions. Solid squares denote estimated aerial counts for unflown days.

2.2.4.4 The boat ramp interview survey

Although aerial surveys can be used to estimate levels of fishing effort at fixed points in time, they tell us nothing about catches, catch rates, harvest, trip durations, or relative levels of effort at other times of the day. The purpose of the aerial counts is to scale up information collected from interviews at a subsample of landing points, to quantify landings from the entire fishery. A companion boat ramp survey is therefore required. Boat ramp interview data can also be used to characterise the fishery, and thus determine the best way of structuring any harvest estimate analysis.

Interview staff were present at key boat ramps throughout SNA 8 on each of the scheduled survey days, regardless of the prevailing weather. Boat ramps were selected throughout SNA 8, to ensure that fishers were encountered along the entire coast, and in all major harbours. Interviewing only took place at the busiest boat ramps in an area, to maximise the number of fishers encountered per survey hour (see Figure 10). There are only a limited number of access points suitable for trailer boats on the west coast, however, and a third to a half of all parties fishing on survey days returned to surveyed ramps, on most days in most areas (see Figure 14).

Two consecutive 6.5 hour shifts were worked at the ramp, with at least one interviewer present at all times. The timing of this 13 hour survey period varied with the time of year, given the timing of dawn and dusk, but always ended at dusk (very few fishers return to boat ramps in the early morning, before the first interviewer would normally arrive). In the summer there was a half hour crossover time, when the morning interviewer worked alongside the afternoon interviewer. This crossover period was longer in the winter months, as the day length shortened.

Interviewers followed a standard interview format, as outlined in section 2.2.1. Interviewers were also instructed to note the time at which each boat returned to the ramp, and classify them as interviewed, interviewed but not fishing, refused but fishing, refused (activity unknown), or not interviewed. From these data it is possible to establish how many boats approached the ramp over any period, and to estimate how many had been fishing, given the proportion of those who had been spoken to that claimed to have been fishing. At busy ramps, or at busy times of day, the interviewer may have been unable to interview all fishing parties approaching the ramp. In such instances, the interviewer was instructed to select boats at random.

Interview data collected at a ramp (or across several ramps servicing an area) throughout each day, can be integrated to describe diurnal changes in levels of: fishing effort (in terms of fishers or boats), harvest (in terms of numbers of fish or weight), and from these, harvest rate. The harvest profile is generated by evenly apportioning a fisher's harvest across the period of time that they claimed to have been fishing. The shape of any form of profile will be distorted when the interviewer noted that a boat returned to the ramp, but was unable to interview the occupants to determine whether, and for how long, the party had been fishing. When there was no information available for a returning boat, we substituted the uninterviewed boat's data with that of the next boat for which data was available. This should not introduce any significant bias in terms of the number, or nature, of boats fishing (or otherwise) if the boats were originally selected at random.

The boat effort profile is of particular importance, as it tells us how many parties claimed to be fishing at the time of the overflight, which is used (in conjunction with the aerial count) to scale up the harvest observed at surveyed ramps, to account for that landed at all points throughout the area assessed, on that day. The total observed harvest for an area is calculated as the area under the harvest profile curve. A more detailed description of this analytical approach with associated formulae is given in Hartill et al. 2007a).

Because of the nature of this analytical approach, it is necessary for interviewers to be present at the ramp throughout a survey day, which necessitates a rigid survey design. If for some reason either the morning or afternoon interviewer was not present for their entire session, all data from that ramp must be discarded on that day. In most areas, however, there was more than one ramp servicing an area, and some description of harvest and effort was still possible. Interviewer absenteeism was a marked problem at two ramps: Weymouth in October/November 2006, and Raglan, on many days between January and March 2007. At Weymouth it took some time to recruit a reliable interviewer, and at Raglan problems were identified with a dishonest interviewer, and most of their data were discarded following critical scrutiny. Problems of this nature are often experienced in surveys of this size, and there are several mechanisms that can be employed to detect these situations. Occasional lapses also occurred at some of the other ramps. In all cases, there was sufficient data available at neighbouring ramps to cover the shortfall, although a smaller fraction of fishers will have been interviewed on these days, in the affected areas. Nonetheless, the survey design was mostly adhered to at almost all ramps on almost all days (Table 6).

Table 6: Summary statistics, by boat ramp, by season, of the number of days surveyed, total hours of interviewing, numbers of parties and fishers interviewed, and numbers of snapper landed at these boat ramps during interview sessions. Interviewing at Raglan and Weymouth only took place on either the morning or afternoon on some days because of unauthorised absenteeism by the interviewer at that time.

Ramp	Season	Days worked	Hours worked	Parties interviewed	Fishers interviewed	Snapper landed
Opononi	Summer	27	322	104	210	428
	Winter	15	169	24	41	66
Tinopai	Summer	29	366	190	332	658
	Winter	16	189	51	68	24
Shelly Beach	Summer	29	363	341	987	2 939
	Winter	16	193	77	244	163
Cornwallis	Summer	28	307	190	384	368
	Winter	16	181	129	214	101
Mangere	Summer	29	361	254	138	199
	Winter	16	188	68	49	5
Weymouth	Summer	28	283	209	384	431
	Winter	16	175	60	120	28
Waiau Pa	Summer	28	337	206	425	348
	Winter	16	195	51	122	16
Raglan	Summer	28	255	294	501	907
	Winter	16	160	94	90	30
Kawhia	Summer	27	312	448	710	1 129
	Winter	16	196	122	188	581
New Plymouth	Summer	29	366	242	516	261
	Winter	15	193	54	77	78
Wanganui	Summer	29	344	388	594	708
	Winter	16	187	105	151	46
Paraparaumu	Summer	29	368	328	626	81
	Winter	16	191	64	110	1
Total	Summer	29	3 985	3 194	5 807	8 457
	Winter	16	2 215	899	1 474	1 139
	2006–07	45	6 199	4 093	7 281	9 596

2.2.4.5 Rationale for selecting analytical areas

Because of the extent of the coastline surveyed, and the varying nature of the snapper fishery across this range, some form of spatial stratification was necessary for analytical purposes. To some extent the definition of these analytical areas was intuitive, because harbour based fisheries were clearly different from those operating on the open coast, and because there were long stretches of relatively unfished coastline, which provided logical break points along the open coast. Boat ramp data were used to assess the degree to which catch compositions differed in each of these areas; specifically comparisons of snapper length compositions, fish bag sizes, and the mix of species landed by interviewed fishers.

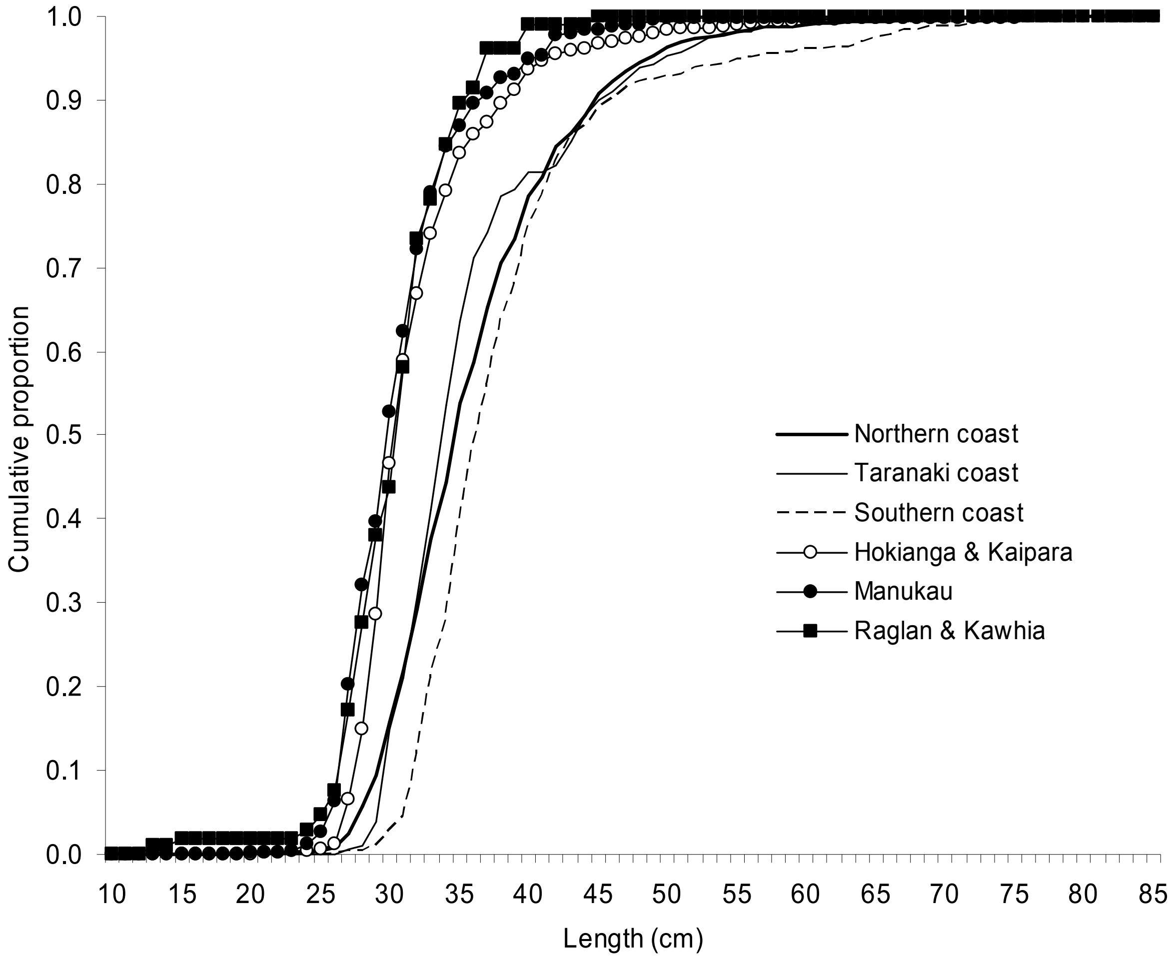


Figure 15: Cumulative length frequency distributions of snapper landed by recreational fishers from six regions of SNA 8.

Anglers fishing in harbours tend to land smaller snapper than their counterparts on the open coast (Figure 15). Although there were slight differences in the size structures of snapper caught in the three harbour strata, these were not considered different enough to warrant allocating these areas into separate spatial strata. More marked differences are evident when length from the three open coast areas are compared, with larger fish being landed in the south.

Fishers in northern waters (on the open coast and in the northern most harbours) land far more snapper, on average, than those fishing in other waters (Figure 16). The incidence of fishers landing snapper is twice as high in the north, where only 30–40% of fishers failed to land snapper, compared to 75–80% to the south. The combined results from these two views of the snapper fishery suggested that SNA 8 should be divided up into five analytical areas. Although fishers in harbours generally land smaller fish than on the open coast, those fishing in the more northern harbours tended to land more fish more often than in the Manukau and to the south, suggesting two harbour groupings; Hokianga/Kaipara, and Manukau/Raglan/Kawhia. Landings on the open coast suggested that the three areas considered should remain separate for analytical purposes, as fishers in the north were generally more successful snapper fishers, although those to the south tended to land larger snapper. A more fine scale stratification was not considered advisable given the low levels of observed fishing effort in this fishery.

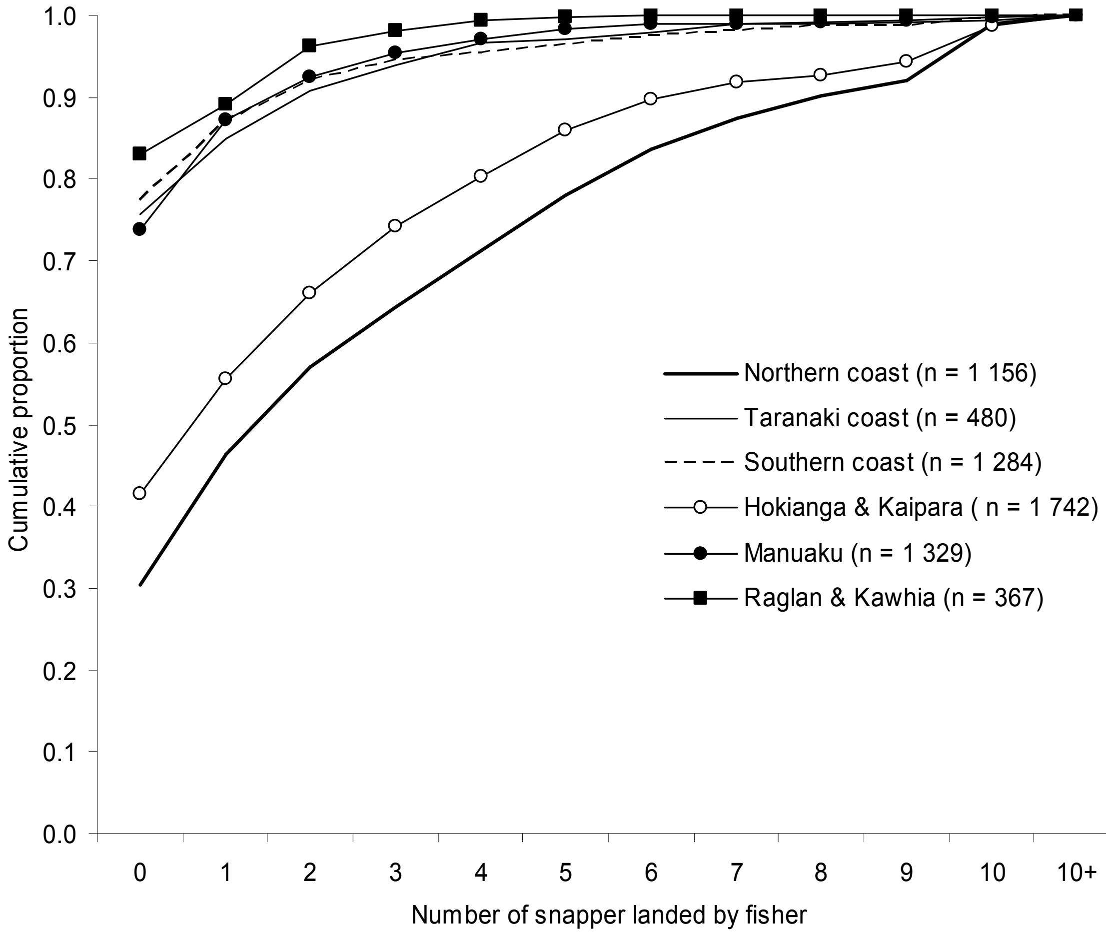


Figure 16: Cumulative frequency of the number of snapper landed per fisher trip from six regions of SNA 8. Numbers in brackets denote the number of fisher interviews in each region.

A further view of the broader recreational fishery is the mix of species landed in different areas (Figure 17). Snapper was the most commonly landed species in all areas except on the southern open coast. Many more species were landed in this area, including appreciable numbers of tarakihi and blue cod, both of which were also commonly landed to a lesser extent on the Taranaki coast. Shallow water species such as grey mullet and flatfish were also commonly caught in the sheltered harbour waters.

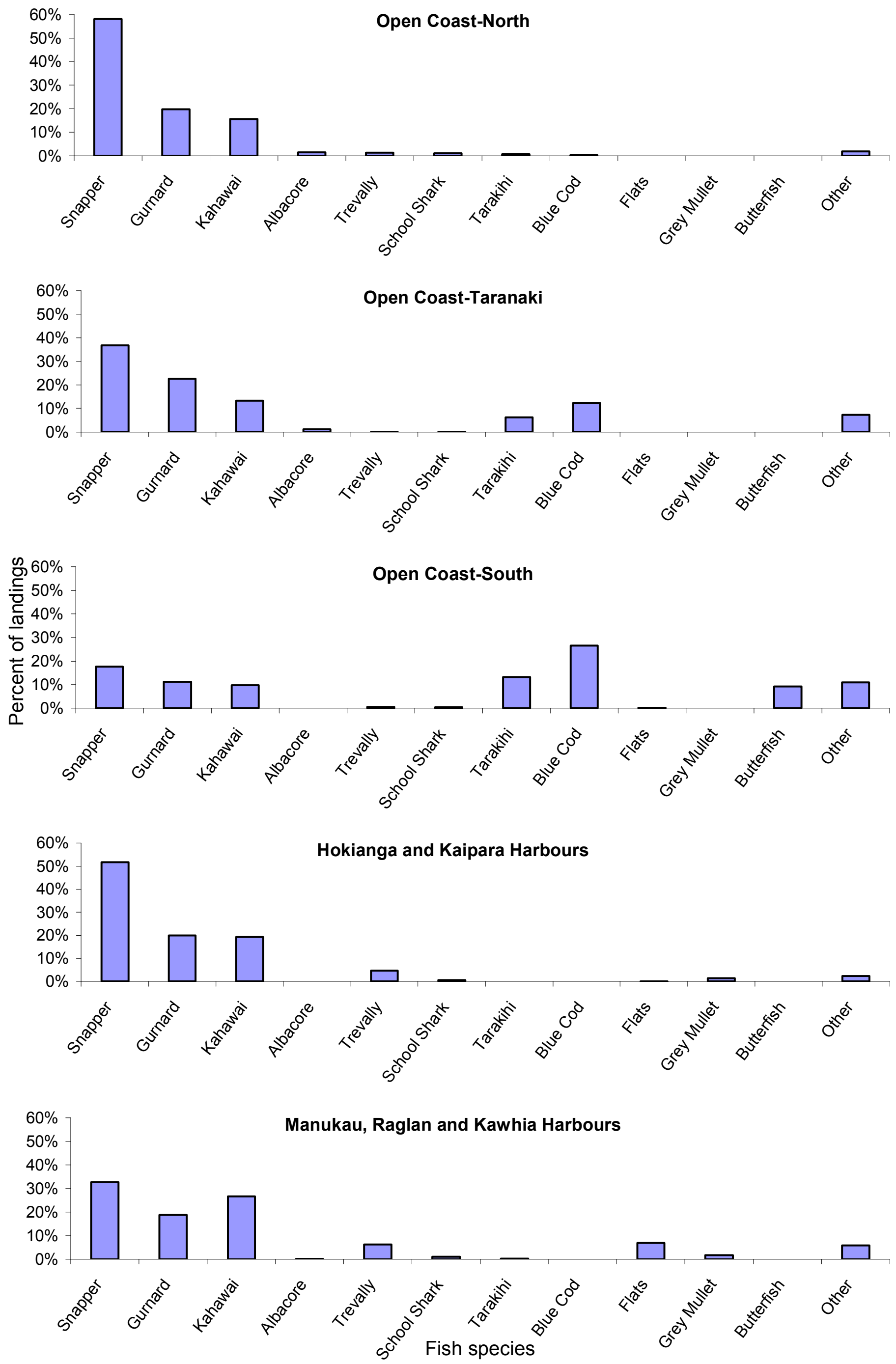


Figure 17: Species composition landed by recreational fishers from six regions of SNA 8.

2.2.4.6 Aerial overflight estimates of the harvest from private vessels

Although interview rates usually resulted in sufficient data to yield meaningful diurnal profiles of fishing effort and harvest for most areas, this was not always the case (Table 7). Usually this was because very little fishing activity took place in some weather conditions, and concomitantly, few fishers were encountered on ramps on these days. This incidence of days when little or no fishing was observed in an area was more pronounced than in previous aerial overflight surveys of other fisheries, which reflects the degree to which fishers have to work around the weather on the west coast.

Table 7: Days on which there were sufficient boat ramp interviews available in a given area to satisfy the criteria given on p. 36. Data meeting these criteria were used to generate diurnal profiles of fishing effort and harvest, which were scaled by aerial counts of fishing boats to give an estimate of the snapper harvest on those days. Instances when a profile was generated are denoted by a "Y".

			Open coast						Harbours			
Season	Day type	Date	North		New Plymouth		South		Hokianga & Kaipara		Manukau, Raglan & Kawhia	
			Profile used	Aerial count	Profile used	Aerial count	Profile used	Aerial count	Profile used	Aerial count	Profile used	Aerial count
Summer	Weekend/ Public holiday	08/10/06	–	2	–	0	Y	16	Y	12	Y	17
		14/10/06	–	1	–	1	–	0	Y	23	Y	15
		29/10/06	–	9	–	0	–	0	Y	12	Y	9
		05/11/06	Y	109	Y	25	Y	6	Y	32	Y	113
		18/11/06	–	9	–	7	–	0	Y	12	–	5
		19/11/06	–	0	–	7	Y	0	Y	7	Y	14
		25/11/06	–	1	–	0	–	0	Y	13	Y	23
		03/12/06	–	1	Y	7	Y	13	Y	12	Y	31
		17/12/06	Y	23	–	7	Y	0	Y	27	Y	43
		29/12/06	–	6	–	6	Y	0	Y	40	Y	27
		02/01/07	Y	75	Y	154	–	0	Y	66	Y	137
		03/01/07	–	21	Y	29	Y	7	Y	80	Y	97
		13/01/07	Y	11	Y	22	Y	164	Y	53	Y	8
		17/02/07	Y	51	Y	101	Y	23	Y	29	Y	62
		24/02/07	Y	49	Y	50	Y	43	Y	56	Y	49
		03/03/07	Y	87	–	120	Y	135	Y	87	Y	93
		10/03/07	Y	105	Y	72	Y	195	Y	80	Y	65
		06/04/07	Y	31	Y	75	Y	205	Y	66	Y	64
		08/04/07	Y	39	Y	104	Y	315	Y	109	Y	114
		Proportion used	0.53		0.53		0.74		1.00		0.95	
	Weekday	12/10/06	–	0	–	0	–	0	–	1	–	1
		25/10/06	–	0	Y	0	–	0	Y	10	–	7
		07/11/06	–	0	–	0	–	0	Y	7	–	5
		24/11/06	–	1	–	0	–	0	Y	5	Y	8
		01/12/06	–	0	–	0	–	0	Y	6	–	7
		06/12/06	–	4	Y	29	Y	25	–	7	Y	19
		08/02/07	Y	25	Y	0	Y	1	Y	3	Y	20
		21/02/07	Y	16	Y	46	Y	13	Y	14	Y	8
		19/03/07	–	1	–	0	–	0	–	6	–	3
		13/04/07	–	0	–	0	–	1	–	0	–	0
		Proportion used	0.20		0.40		0.30		0.60		0.40	
Winter	Weekend/ Public holiday	27/05/07	–	1	–	1	Y	4	Y	4	–	1
		02/06/07	–	0	–	7	–	0	Y	30	Y	18
		30/06/07	–	0	–	7	–	0	–	0	–	5
		14/07/07	Y	81	Y	73	Y	68	Y	20	Y	57
		04/08/07	–	4	–	7	Y	3	Y	1	Y	13
		11/08/07	–	0	–	0	–	0	Y	15	Y	19
		26/08/07	Y	26	Y	24	–	4	Y	18	Y	57
		29/09/07	Y	120	–	14	Y	27	Y	45	Y	65
		Proportion used	0.38		0.25		0.50		0.88		0.75	
	Weekday	08/05/07	Y	4	Y	13	Y	9	Y	13	Y	7
		18/05/07	–	1	–	2	–	1	Y	4	Y	6
		29/06/07	–	0	–	0	Y	5	–	0	Y	2
		20/07/07	Y	5	–	0	Y	6	Y	6	Y	8
		03/08/07	–	0	–	0	Y	9	Y	4	Y	2
		08/08/07	–	0	–	3	–	0	–	5	–	4
		03/09/07	–	0	–	0	–	0	Y	8	Y	17
		12/09/07	Y	7	–	21	Y	7	Y	18	Y	24
		Proportion used	0.40		0.13		0.63		0.75		0.88	
		Overall proportion used	0.40		0.38		0.58		0.84		0.78	

The criteria for deciding whether or not meaningful profiles of fishing effort and harvest could be derived were as follows.

1) Ignore a day's data if boat ramp interviewers did not encounter any fishers who had fished in a given area.

2) Ignore all boat ramp interview data on those days when the number of boats observed from the air in a given area was thirty or more times greater than the number of boats interviewed at boat ramps which reported fishing activity at the time of the overflight. This only occurred once, in the Taranaki area.

3) Ignore interview data on those days when aerial counts suggested that one or more boats fished a given area, but none of the fishers encountered by boat ramp interviewers reported any fishing activity in that area at the time of the overflight. This situation occurred 20 times, although only between 1 and 37 hours of fishing were reported by interviewed fishers in these cases, and the aerial counts were also correspondingly low. The incidence of snapper being landed in these cases was very low; a total of 48 snapper.

Often, more than one of these criteria applied in a given analytical area on a given survey day.

Combinations of days and areas where these criteria were met are given in Table 7. There was a higher incidence of rejection for weekday strata days; more so on the open coast, which is less hospitable in rougher weather. Nonetheless, profiles were generated for at least half of the days sampled in most strata.

On days when there were insufficient interview data to build a meaningful profile, a profile was still required to describe changes in harvest and effort throughout the day. These were imputed by averaging the meaningful profiles from the same seasonal/day type/area stratum. For most of the days when imputed profiles were required, their use would have created very little bias in the final harvest estimate, as aerial counts suggest that very little effort and harvesting occurred on these days.

All profiles were then scaled up to account for fishers who would have returned to unsurveyed access points. This was done by dividing the aerial count for an area by the number of interviewed parties who claimed to be fishing in that area at the time of the overflight, as determined from the unscaled boat effort profile. Area-specific snapper harvest estimates were then generated for each survey day, by summing up the area under the harvest profile. These daily harvest estimates were then averaged and weighted up on the basis of the number of days occurring in each seasonal/day-type stratum, with the estimates for each stratum combined to give the annual SNA 8 trailer boat harvest estimate.

Variance estimates were generated for each spatio/temporal stratum by a bootstrapping procedure. Survey days from each seasonal/day-type/area stratum were selected with replacement. In turn, data from fishing parties interviewed on that day were selected with replacement, and were used to construct profiles of fishing effort, harvest, and harvest rate. Each bootstrapped profile was then scaled up by the aerial count on the associated day. When there were insufficient interview data for profiling on the selected day, profile data were selected at random from one of the stratum days which met the three criteria above. Bootstraps were performed 1000 times, from which mean, median, and 5% and 95% percentile profiles were generated. The distribution of these is given in Appendix 1.

The aerial overflight method does not account for vessel-based harvests resulting from trolling, longlining, and set netting. We used boat ramp interview data on the number of snapper taken by these methods to estimate that they only accounted for 1.49% of the observed harvest. All aerial overflight harvest estimates and associated bootstraps were scaled up to account for this relatively minor source of harvest. Variance estimates were calculated by bootstrapping the data used to derive the 1.49% estimate, and then applying these bootstrapped scalars to the bootstrapped aerial overflight estimates.

2.2.5 Combining harvest estimates from all fishery components

Estimates of the recreational harvest of snapper taken from private boats, from the shore, and from charter boats, can be combined to provide an estimate of the overall recreational take from SNA 8 in 2006–07 (Table 8). The order in which these components are considered is important, because of the underlying data sources and the manner in which some of the estimates were derived. The sector of the recreational fishery that accounts for most of the snapper harvest is the trailer boat fleet. The aerial overflight estimate of the harvest taken by this fleet is 160.3 tonnes. This estimate is the sum of estimates calculated for each of the five analytical areas (Table 8). The addition of the estimate of a further 1.49% of the fleet's harvest by fishing methods that are not easily assessed from the air increases the harvest estimate to 162.7 t.

Table 8: Estimates of the recreational harvest of snapper in five spatial strata of SNA 8 with associated bootstrap statistics. Overflight survey estimates are adjusted in the second half of the table to account for harvests by vessel-based fishing methods which were not estimated by the overflight approach, the harvest by shore-based fishers, and the harvest reported by charter boat operators.

Area	Estimate	Mean of bootstraps	Median of bootstraps	5th percentile	95th percentile	c.v.
Northern Open Coast	63.2	63.8	62.1	36.9	93.6	0.28
Taranaki Open Coast	19.2	18.4	17.6	8.6	28.7	0.34
Southern Open Coast	19.7	20.6	19.6	8.5	32.9	0.37
Hokianga & Kaipara Harbours	47.7	48.7	47.8	34.3	64.9	0.20
Manukau, Raglan & Kawhia Harbours	10.5	11.1	10.6	6.3	16.2	0.28
SNA 8 2006–07 survey total	160.3	162.6	160.4	126.7	202.1	0.14
Scaled to account for 1.49% of harvest by unassessed vessel based methods[1]	162.7	163.9	162.7	128.5	205.3	0.14
Scaled to account for 9.1% of harvest by shore based methods[2]	178.9	180.2	179.3	140.7	224.9	0.14
Including harvest reported by SNA 8 charter boat operators of 81.6 t	260.5	261.7	260.2	222.0	307.1	0.10

1 - Derived from concurrent boat ramp interview data
2 – Derived from diarist data collected in 2001

This estimate is then scaled up to account for the harvest taken from the shore. The pilot survey conducted in 2005–06 suggested that the shore based harvest is about 8.5% of the recreational take from SNA 8. Although this estimate is based on observations on a limited number of weekend days during the summer, it is the only information that we have based on a direct observation of the fishery. The results from the most recent telephone/diary survey in 2001 give a very similar estimate of 8.4%. Given this similarity in estimates, we used the diarist data collected in 2001 to account for the shore based harvest, as it was more amenable to bootstrapping. The scalar used in this case was 9.1% as we removed charter boat trips from the diarist data first, as we account for the harvest from this fleet at a later stage. Scaling the harvest from private boats up to provide for the shore based harvest increased our estimate up to 178.9 t.

The final adjustment is for the harvest caught from charter boats. When the reported harvest of 81.6 t derived from a census of the charter fleet is added to estimates for the other two forms of recreational fishing, we estimate that the overall recreational harvest from SNA 8 in 2006–07 was 260.5 t. Variance associated with the charter boat harvest estimate was generated by parametrically bootstrapping from a normal distribution with a mean of 81.6 t and a c.v. of 5%.

Bootstrap estimates associated with the initial aerial overflight estimates were combined with bootstrapped values for all of the following stages, in the manner outlined above. These were used to calculate c.v.s at each stage, for each sub area of SNA 8, and for the overall stock. Charter boat harvest tonnages were broken down by sub area when required. Distributions of aerial overflight bootstrap estimates for each area, with associated expanded harvest estimates and c.v.s, are given in Appendix 1.

2.2.6 Representativeness of sample days

Web cameras were installed overlooking boat ramps at: Shelly Beach in the Kaipara harbour (06/07/06), Cornwallis in the Manukau Harbour (07/08/06), and at New Plymouth (06/12/06). The purpose of these cameras was to assess how representative the selection of survey days was, and to monitor long term changes in fishing effort levels. There were appreciable delays with the installation of the camera in New Plymouth and data availability problems with the reliability of this system were experienced for some time afterward. Continuous minute by minute imagery is available from the Shelly Beach and Cornwallis Beach cameras, however, which can be used to assess how representative the survey day sample was, in terms of boat ramp traffic levels (Table 9).

Table 9: Number of days when there is a full 24 hours of web camera footage of activity at Shelly Beach and Cornwallis Beach boat ramps during the survey period 1 October 2006 to 30 November 2007.

Year	Month	Shelly Beach	Cornwallis Beach
2006	October	31	31
	November	30	23
	December	31	31
2007	January	31	30
	February	26	28
	March	31	31
	April	29	25
	May	31	30
	June	30	30
	July	30	31
	August	31	31
	September	30	30
Total		361	351

Daily levels of traffic at these ramps (and presumably fishing effort) were highly variable (Figure 18). Fishing effort was generally higher during weekends and public holidays, more so at Shelly Beach. There was a steady and substantial level of activity at the ramps between December and February, with marked peaks corresponding to public holidays such as Waitangi Day, Easter weekend, and Anzac Day. Public holidays were particularly busy at Shelly Beach.

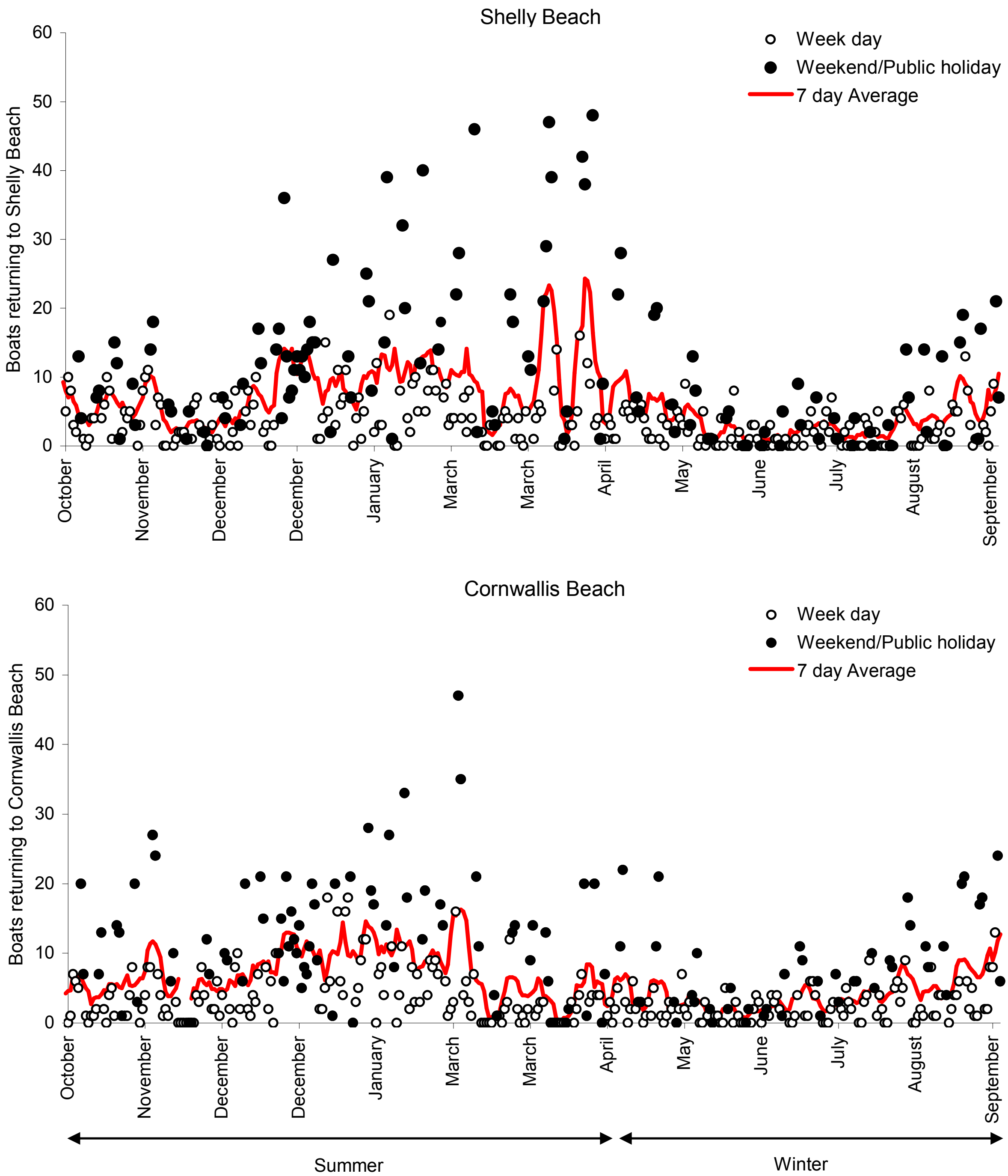


Figure 18: Daily web camera based counts of trailer boats returning to ramps at Shelly Beach (upper panel) and Cornwallis Beach (lower panel) between 1 October 2006 and 30 November 2007. Closed circles denote weekend days and public holidays, open circles denote mid week days and lines denote seven day moving averages.

Cumulative comparisons of daily boat ramp traffic rates on survey days, relative to those on all days, suggests that there may have been a slight bias towards surveying on low effort days in some temporal strata, more so at the Shelly Beach ramp (Figure 19). Disproportionate selection of quieter fishing days will result in an underestimate of the harvest from the private boat fleet. The harvest estimate of 260.5 t for all components of the SNA recreational fishery may, therefore, be negatively biased to a small degree, given any downward bias associated with disproportionate selection of quieter fishing days for the private vessel harvest estimate.

2.2.7 Unobserved harvests at surveyed ramps

A key assumption of the aerial overflight approach is that boat ramp interviewing throughout the day provides a census of the harvest landed to that ramp on a survey day. Web camera imagery can be used to quantify the number of boats (and potentially harvest) missed by the boat ramp interviewer on each survey day. There are two ways in which boats returning to the ramp can be overlooked. The interviewer can either fail to note that a boat has returned to the ramp because they are otherwise distracted, or, a boat could return to the ramp after dusk, when the interviewer has left for the day.

In most instances the failure to observe a boat will lead to an underestimate of the harvest, but this is not always the case. Firstly, not all boats returning to the ramp will land a recreational catch of snapper. This could be because the fishing trip was not successful, or because the boat was being used for another purpose, such as water skiing or commercial fishing (37% of the boats returning to the Shelly Beach ramp were classified as commercial fishing vessels, which were also far more likely to return to the ramp outside of survey hours). Secondly, if an unobserved vessel was fishing at the time of the overflight, failure to account for this vessel will lead to an inflated flight to ramp count ratio for that day, which will lead to an over inflation of the censused harvest. Any estimate of negative bias associated with missed boats will, therefore, be an overestimate, although a comparison of camera and interviewer counts may provide an upper bound for any bias estimate.

The results of comparisons between camera and interviewer counts are, however, ambiguous. There are marked discrepancies between these two sources of information. At Shelly Beach the interviewer count is on average 15% lower than the camera count, but at Cornwallis it is 1% higher (Table 10). These are counts of all vessel types, both commercial and non commercial. If counts of boats classified as recreational are compared, then the ramp interviewers counted 8% more boats than were counted by the image interpreter (there was no change at Cornwallis).

The relationship between daily camera and interviewer counts of vessels returning to Shelly Beach (in the case of all vessels and when only recreational vessels are considered) is plotted in Figure 20. The plots demonstrate how variable the relationship is between daily counts of any magnitude. If the interpretations of web camera footage were correct (and the boat ramp interview data was recorded honestly and without clerical error), then interviewer counts of vessels should be either less than or equal to those derived from camera footage (because the interviewer was distracted or because vessels came in after dark). This is not the case.

These discrepancies are probably largely due to how a vessel is classified. Shelly Beach is a popular launch site for many commercial fishers, and although the interviewers were familiar with many of these fishers, image interpreters will have greater difficulty determining whether or not a boat has been used for commercial purposes. This is partially because some recreational fishers use the same tractor as some of the commercial fishers, and because boats are often unloaded outside of the field of view. Also, many commercial vessels return to the ramp after dark, although there is some artificial lighting available.

From these analyses we conclude that although boat ramp interviewing may have failed to account for up to 15% of the harvest landed at Shelly Beach, the likely level of bias is probably much lower. There does not appear to be any substantial bias due to missed boats at Cornwallis Beach (although the land behind the ramp is obscured by a group of trees).

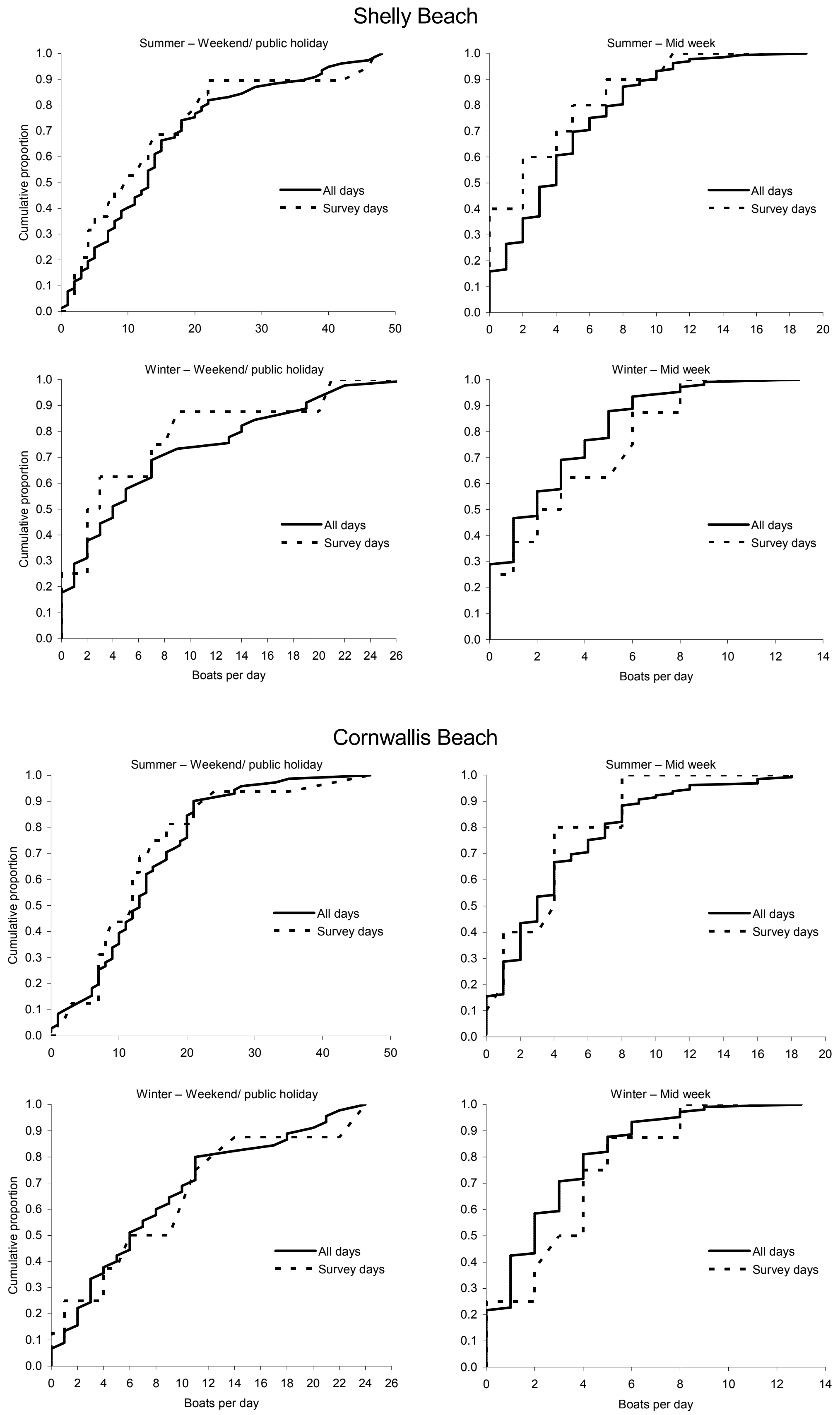


Figure 19: Comparisons of daily boat ramp traffic rates on survey days relative to the numbers observed on all days, including survey days. The number of days is expressed cumulatively in terms of increasing daily traffic rates for each of the four seasonal/day type strata.

Table 10: Comparisons of counts of the number of boats (recreational and commercial) landed at the Shelly Beach and Cornwallis Beach boat ramps on survey days. Camera counts are based on web camera imagery collected over a full 24 hour period, and interviewer counts are for the hours surveyed (up to 13 hours ending approximately at dusk).

Survey	Shelly Beach			Cornwallis Beach		
Date	Camera	Interviewer	Missed	Camera	Interviewer	Missed
08/10/06	4	2	2	7	4	3
12/10/06	4	0	4	1	2	-1
14/10/06	7	4	3	7	9	-2
25/10/06	7	3	4	1	1	0
29/10/06	5	2	3	3	3	0
05/11/06	20	21	-1	–	–	–
07/11/06	11	6	5	–	–	–
18/11/06	2	1	1	–	–	–
19/11/06	6	3	3	–	–	–
24/11/06	5	1	4	4	10	-6
25/11/06	–	–	–	12	7	5
01/12/06	3	1	2	–	–	–
03/12/06	5	6	-1	9	11	-2
06/12/06	6	2	4	8	6	2
17/12/06	19	18	1	–	–	–
29/12/06	15	17	-2	12	10	2
02/01/07	22	21	1	–	–	–
03/01/07	16	12	4	–	–	–
13/01/07	4	4	0	1	0	1
08/02/07	–	–	–	–	–	–
17/02/07	20	19	1	17	19	-2
21/02/07	12	10	2	8	8	0
24/02/07	17	19	-2	17	15	2
03/03/07	25	23	2	47	37	10
10/03/07	50	50	0	21	22	-1
19/03/07	0	1	-1	1	2	-1
06/04/07	23	20	3	13	15	-2
08/04/07	53	51	2	–	–	–
13/04/07	0	0	0	0	0	0
08/05/07	13	10	3	0	2	-2
18/05/07	2	3	-1	5	5	0
27/05/07	2	5	-3	0	0	0
02/06/07	4	3	1	4	3	1
29/06/07	1	1	0	0	0	0
30/06/07	1	0	1	1	1	0
14/07/07	14	12	2	–	–	–
20/07/07	9	6	3	4	5	-1
03/08/07	5	3	2	2	3	-1
04/08/07	2	2	0	6	7	-1
08/08/07	9	4	5	3	1	2
11/08/07	5	5	0	10	12	-2
26/08/07	15	10	5	15	18	-3
03/09/07	13	10	3	8	8	0
12/09/07	14	6	8	4	7	-3
29/09/07	24	21	3	24	24	0
Total	494	418	76	275	277	-2

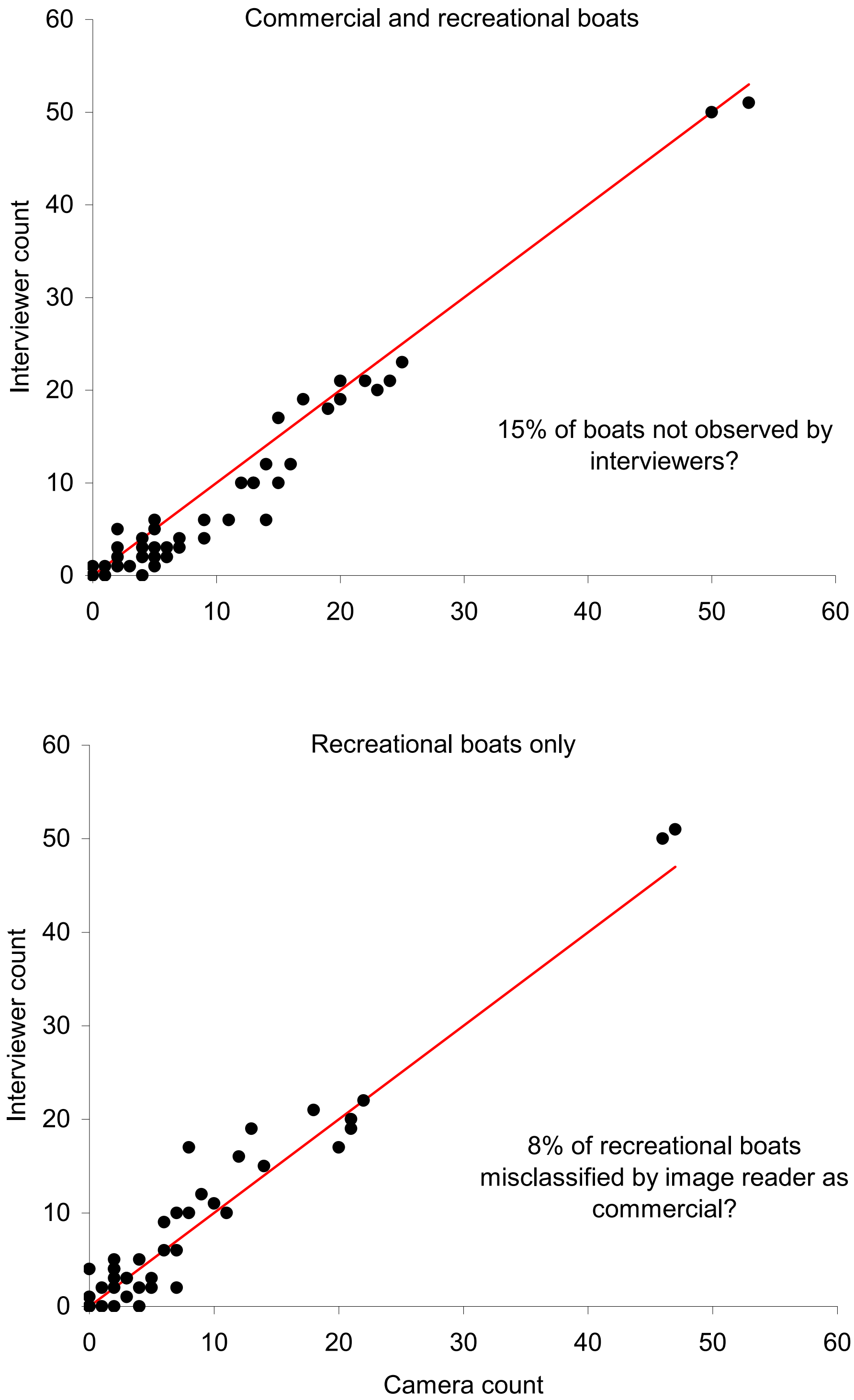


Figure 20: Comparisons of daily counts of recreational fishing vessels made by interviewers with those derived from web camera imagery collected on the same day. The web camera counts in the upper panel include boats that may have potentially fished commercially (set net dories), whereas the counts in the lower panel do not include counts of these vessels. The text in each panel gives a possible explanation for the discrepancy observed between interviewer and image based counts.

2.2.8 Utility of web camera data in SNA 8

Analyses of web camera data collected in QMA 1 suggests that this approach is a viable means of generating a proxy index of recreational effort (Hartill et al. 2007c). Further work will be required to develop web camera systems in SNA 8, however, for reasons which are ramp specific.

At Shelly Beach it is hard to distinguish between commercial and recreational vessels given the current field of view of the web camera. Commercial effort will, therefore, contaminate any putative index of recreational fishing effort to an unknown degree. Commercial fishers also use other access points on this harbour. The proposed solution is to install a second higher resolution camera, with an alternative view of the ramp. The provision of two concurrent images of the ramp should give the image readers far more information that can be used to distinguish commercial vessels from recreational vessels.

The incidence of commercial landings appears to be far lower at Cornwallis Beach, but there are other issues associated with this ramp. The best field of view overlooks a group of trees, which obscures the parking area, and any growth of these protected pohutukawas will eventually mask the ramp. Perhaps of greater concern is the fact that this ramp is used both by parties fishing in the harbour, and those fishing on the open coast. This is likely to be the case for all landing points in the Manukau Harbour, as there have been reports of open coast fishers departing from as far east as Mangere Bridge. An image interpreter will not be able to distinguish between these two groups of fishers, yet the tendency to go fishing in these two bodies of water will differ considerably given weather conditions. Fishing can take place in the harbour under almost any weather conditions, but access to the open coast is often not possible given the sea state and that of the harbour bar. Fishing success in these two bodies of water is also very different (see Figures 15 and 16). We suggest that this system should be moved to another site, possibly at Raglan.

The most promising site, in terms of viability, is at New Plymouth, although continuous coverage is hard to achieve here because of technical issues including sun strike, which are not resolvable. NIWA is currently exploring the possibility of moving this camera to the opposite side of the boat ramp, and transferring to a higher resolution system.

Ongoing development of web camera systems is therefore required to overcome the issues identified above. These systems have, however, provided a means of assessing how representative the selection of days surveyed in 2006–07 was, in terms of boating effort. Changes in recreational harvest and effort could be monitored by conducting on-site harvest estimation surveys on a regular basis, perhaps following the methodology used in this programme.

3. CONCLUSIONS

A 10 day pilot survey was conducted in the summer of 2005–06, to determine whether aerial overflight methods could be used to estimate the recreational harvest from SNA 8. The findings of this pilot survey were:

- That the aerial overflight method could be used to assess the boat based harvest of snapper on the west coast of the North Island.

- That a comparison of counts of fishing vessels made during four flights throughout each survey day suggested that fishing effort usually (but not always) peaked in the late morning. The consistency of this diurnal profile of effort supported the adoption of the single flight maximum count methods developed previously to assess recreational harvests in QMA 1.

- Aerial counts of shore based fishers combined with concurrent interview data suggested that these fishers accounted for approximately 9 % of the total recreational harvest taken from SNA 8, and that this was mainly taken by longline. A similar estimate was obtained from the

2000–01 telephone diary programme. The decision was made not to estimate shore based harvests from the air because of difficulties with identifying individual anglers from an altitude of 500 feet with any certainty, and because direct estimation of this harvest was not warranted given the low level of harvest taken by dispersed shore based fishers.

A full 12 month survey of the SNA 8 fisher was conducted in the following 2006–07 fishing year. The findings of this survey were:

- The aerial overflight estimate of the harvest from private vessels in SNA 8 in 2006–07 is 160.3 t, which increases to 162.7 t (with 95% confidence intervals of 128.5 t and 205.3 t) once harvest by trolling, longlining and set netting are taken into account.

- When data from the 2000–01 telephone diary survey are used to scale up this estimate to account for the additional harvest taken by shore based fishers, the recreational SNA 8 harvest estimate increased to 178.9 t (with 95% confidence intervals of 140.7 t and 224.9 t).

- A logbook system was used to estimate the harvest taken by recreational fishers from the 25 charter boats that we able to identify as operating in SNA 8 in 2006–07. Most charter boats returned data for a full 12 month period, but some imputation was required to estimate the harvest taken from three vessels, and a small number of minor operators provided a single estimate for the entire 12 month period. We estimate that the total charter boat harvest over this 12 month period was 81.6 t (with 95% confidence intervals of 77.4 t and 85.7 t).

- When harvest estimates for the fleet of private boats, shore based fishers, and for those fishing from charter boats are combined, we estimate that the total recreational harvest from SNA 8 in 2006–07 was 260.5 t (with 95% confidence intervals of 222.0 and 307.1).

- The selection of survey days during the 2006–07 aerial overflight survey appears to be slightly biased towards low effort days, as inferred from web camera counts of boats returning to Shelly Beach in the Kaipara Harbour, and Cornwallis in the Manukau Harbour. The harvest estimate for all SNA 8 recreational fisheries will be an underestimate for this reason, probably to a very small degree.

We suggest that any similar survey in the future should consider the following recommendations:

- The cost of aerial surveying north of South Kaipara Head is not warranted given the very low level of effort observed during flights in 2006–07. The boat based harvest of snapper taken on this stretch of coast is likely to be negligible.

- Charter boat based harvest should be assessed via the charter boat log book scheme introduced by the Ministry of Fisheries in 2010.

- Further development of web camera systems currently installed at Shelly Beach and New Plymouth is required because of shortcomings identified during this programme. The web camera overlooking Cornwallis should be moved to monitor trends in fishing effort in the waters off Raglan.

4. ACKNOWLEDGEMENTS

This work was funded by the Ministry of Fisheries under project REC2005/01. The authors wish to thank the numerous aerial observers and boat ramp interviewers who made this study possible. We are also grateful to the charter boat operators who cooperated with the logbook survey and to fishers who participated in boat ramp interviews. The Marine Amateur Fisheries Working Group provided a useful review that helped to improve this report.

5. REFERENCES

Boyd, R.O.; Gowing, L.; Reilly, J.L. (2004). 2000–2001 national marine recreational fishing survey: diary results and harvest estimates. Draft New Zealand Fisheries Assessment Report. 81 p.

Bradford, E. (1998). Harvest Estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 98/16. 27p. (Unpublished report held by NIWA library, Wellington).

Davey, N.; Hartill, B.; Cairney, D.G.; Cole, R.G. (2008). Characterisation of the Marlborough Sounds recreational fishery and associated blue cod and snapper harvest estimates. *New Zealand Fisheries Assessment Report 2008/31*. 63 p.

Department of Conservation (1991). How many fish are caught at Taupo? Target Taupo. Special edition 1, Turangi, New Zealand Department of Conservation.

Hartill, B.; Bian, R.; Armiger, H.; Vaughan, M.; Rush, N. (2007b). Recreational marine harvest estimates of snapper, kahawai and kingfish in QMA 1 in 2004–05. *New Zealand Fisheries Assessment Report 2007/26*. 44 p.

Hartill, B.; Bian, R.; Davies, N. (2008). Review of recreational harvest estimates and approaches. Final Research Report for Ministry of Fisheries Project REC200506. 56 p. (Unpublished report held by MFish, Wellington).

Hartill, B.; Payne, G.; Reddish, L.; Vaughan, M.; Spong, K.; Buckthought, D. (2007c). Monitoring recreational fishing effort in QMA 1. Final Research Report for Ministry of Fisheries research project REC200506, Objective 1. 18 p. (Unpublished report held by MFish, Wellington).

Hartill, B.; Watson, T.; Cryer, M.; Armiger, H.; Bian, R. (2007a). Recreational harvest estimates of snapper and kahawai in the Hauraki Gulf. *New Zealand Fisheries Assessment Report 2007/25*. 54 p.

Hoenig, J.M.; Robson, D.S.; Jones, C.M.; Pollock, K.H. (1993). Scheduling counts in the instantaneous and progressive count methods for estimating sportfishing effort. *North American Journal of Fisheries Management 13*: 723–736.

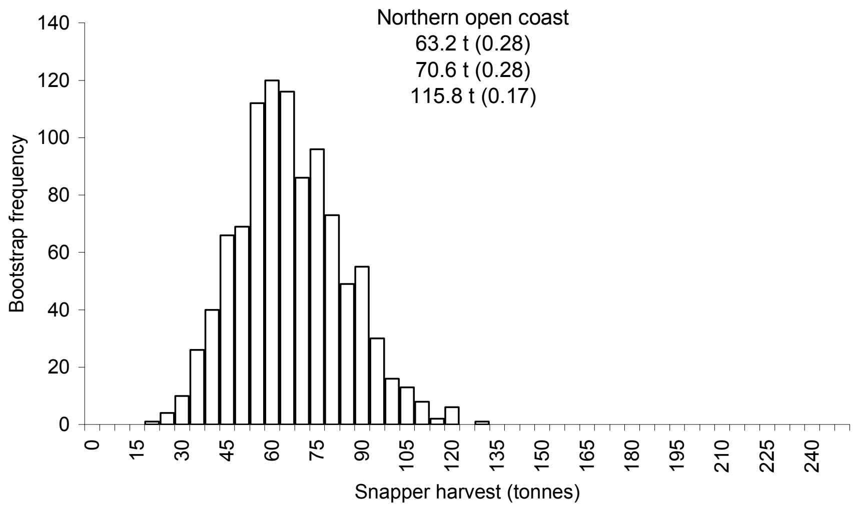
Paul, L.J. (1976). A study on age, growth and population structure of the snapper, *Chrysophrys auratus* in Hauraki Gulf. *N.Z. Fisheries Research Bulletin*. Ministry of Agriculture and Fisheries New Zealand 13: 63 p.

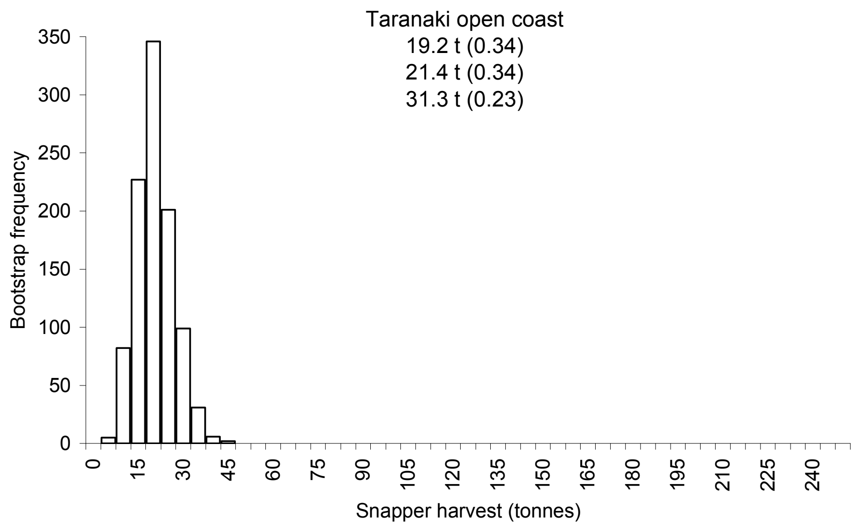
Pierce, R.B.; Bindman, A.G. (1994). Comparison of absolute fishing effort and hourly instantaneous angler counts in a small lake. *North American Journal of Fisheries Management 14*: 447–448.

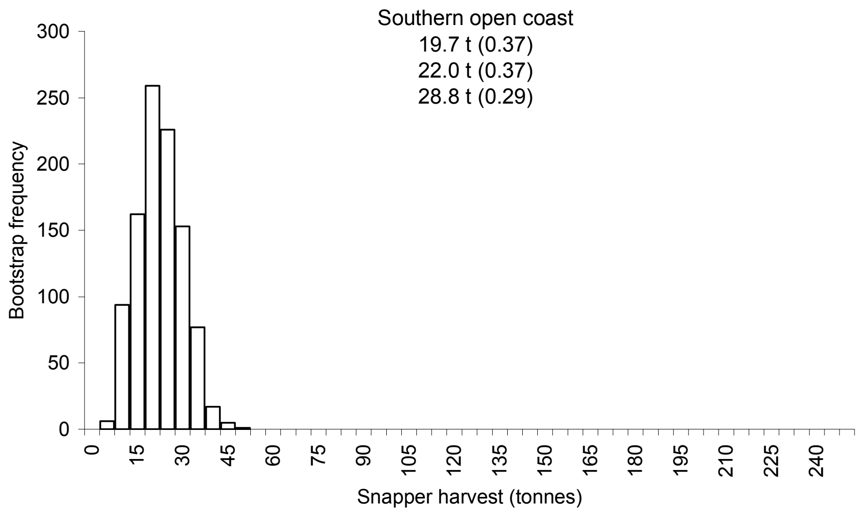
Pollock, K.H.; Jones, C.M.; Brown, T.L. (1993). Angler survey methods and their applications in fisheries management. *American Fisheries Society Special Publications 25*. 371 p.

Teirney, L.D.; Kilner, A.R.; Millar, R.B.; Bradford, E.; Bell, J.D. (1997). Estimation of Recreational Harvests from 1991–92 to 1993–94. New Zealand Fisheries Assessment Research Document 97/15. 43 p. (Unpublished report held by NIWA library, Wellington).

Appendix 1: Distribution of bootstrapped estimates of the harvest in SNA 8 by area. The three harvest estimates given in each figure are the harvest from private vessels, the harvest with additional allowance for shore fishing, and the harvest with the addition of the landings reported by charter boat operators in that area. Numbers in brackets denote c.v.s associated with these estimates.







Appendix 1 continued: Distribution of bootstrapped estimates of the harvest in SNA 8 by area. The three harvest estimates given in each figure are the harvest from private vessels, the harvest with additional allowance for shore fishing, and the harvest with the addition of the landings reported by charter boat operators in that area. Numbers in brackets denote c.v.s associated with these estimates.