Ministry for Primary Industries
Manatū Ahu Matua

Recreational fishing effort indices for FMA 1 from 2004–05 to 2011–12 and for FMAs 8 and 9 from 2006–07 to 2011–12

New Zealand Fisheries Assessment Report 2015/50.

B. Hartill,
N. Rush,
A. Miller,
R. Bian,

ISSN 1179-5352 (online)
ISBN 978-1-77665-039-2 (online)

September 2015

New Zealand Government

Growing and Protecting New Zealand

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-resources/publications.aspx
http://fs.fish.govt.nz go to Document library/Research reports

Contents

EXECUTIVE SUMMARY

Hartill, B.; Rush, N.; Miller, A.; Bian, R. (2015). Recreational fishing effort indices for FMA 1 from 2004–05 to 2011–12 and for FMAs 8 and 9 from 2006–07 to 2011–12.

***New Zealand Fisheries Assessment Report 2015/50.* 19 p.**

Web cameras have been used to monitor trends in recreational traffic returning to key boat ramps since 2004 in FMA 1, 2006 in FMA 8, and 2007 in FMA 9. Each web camera system captures a time stamped image every minute of the day, and these images are interpreted in series to determine the number of boats returning to the ramp on that day. Images are interpreted from 60 days per calendar year, selected according to a stratified random sampling design. Seasonal and annual indices of effort are then calculated from these data for regions within FMAs 1, 8, and 9. This report updates existing indices of effort for the 2009–10, 2010–11 and 2011–12 fishing years.

Trends in effort in the three regions of FMA 1 (East Northland, the Hauraki Gulf, and the Bay of Plenty) were each monitored by a single camera system, although unused data have also been collected by systems at secondary ramps which were also installed in early 2005. A full series of 1440 minute-by-minute images are available for most, but not all of the 60 days preselected from each fishing year, as system outages occasionally occur for a variety of fishery independent reasons. When these outages occur, the level of effort that would have occurred at the affected ramp is predicted from that occurring in the remaining two regional ramps. These predictions for outage affected days appear to be sensible given the high degree of correlation observed between relative trends in effort across all three regions. Indices of effort generated using observed and predicted daily traffic count data from the three regions of FMA 1 differ to some degree, but a common trend is still evident across all three indices. Levels of effort in all three regions of FMA 1 appear to have initially declined from 2005–06 onwards, but then peaked in 2010–11, followed by a marked decline in 2011–12.

Only a single camera is used to monitor effort in FMA 8, at New Plymouth. Effort at this ramp peaked in 2006–07 and in 2010–11, followed by the same marked decline in effort in 2011–12.

Effort is monitored at two ramps in FMA 9; at Shelly Beach in the Kaipara Harbour, and on the open coast, at Manu Bay/ Raglan Harbour entrance. These two sites represent two “regional’ aspects of the recreational fishery in FMA 9, as the large sheltered Kaipara and Manukau harbours experience different fishing and environmental conditions to the more exposed waters on the open coast. Recreational effort at Shelly Beach appears to have also peaked in 2010–11, followed by a marked decline in traffic in the following year. The system at Raglan has only been fully operational since the winter of 2009–10, but a marked decline in effort was also evident at this site, between 2010–11 and 2011–12.

These web camera based indices of recreational effort, coupled with harvest estimates provided by surveys of New Zealand’s recreational fisheries in 2011–12 provide some insight into how levels of recreational harvesting may have changed in recent years. The trends seen at all six ramps suggest that harvest estimates derived from surveys of New Zealand’s recreational fisheries in 2011–12 were obtained in a year when levels of fishing effort were suppressed during the busier summer months. Analyses which are not presented here also strongly suggest that recreational snapper catch rates have increased in the Hauraki Gulf in recent years. This means that projecting these harvest estimates into the future potentially underestimates the impact that some recreational fisheries will have in coming years.

1. INTRODUCTION

Considerable progress has been made in recent years towards developing more reliable harvest estimation techniques, but it is highly likely that future harvest estimation surveys will be conducted intermittently because of the expense involved. Levels of recreational harvesting can vary substantially over time, however, and some form of interpolation is required to properly account for the impact that recreational fishers have on inshore fish stocks.

In recent years a network of web cameras has been established overlooking key boat ramps throughout FMAs 1, 8 and 9. These cameras provide a potentially cost effective and reliable means of monitoring relative trends in recreational fishing effort, which is a key driver of recreational harvesting levels. A recent analysis of image data collected and interpreted from a network of cameras overlooking boat ramps in FMA 1, suggests that these systems can potentially provide a reasonably reliable means of monitoring changes in levels of recreational boating effort in East Northland, Hauraki Gulf, and the Bay of Plenty (Hartill et al. 2007). This analysis has shown that a random stratified sample of 60 days per fishing year can be used to provide reasonably precise estimates of the number of vessels returning to a given boat ramp during a season or twelve month period, and that it may be possible to create an index of fishing effort based on a time series of these estimates.

This report describes a process for generating indices of effort based on a random stratified sample of 60 days per fishing year. A method is also given for imputing estimates of boat ramp traffic in FMA 1 on those days when system outages occur, based on web camera counts made at ramps in neighbouring regions on the same day. Indices of recreational effort based on web camera data are provided here for three sub-regions of FMA 1: East Northland, the Hauraki Gulf, and the Bay of Plenty, for the open coast fishery in FMA 8, and for the harbour and open coast fisheries in FMA 9.

The overall objective of this research was to monitor changes in recreational fishing effort in FMAs 1, 8 and 9. The specific objective was to derive regional indices of recreational fishing in FMA 1, FMA 8 and FMA 9 using web camera data collected from boat ramps for the 2009/10, 2010/11 and 2011/12 fishing years.

2. METHODS

Since early 2004 web cameras have been used to monitor the rate at which boats return to a selection of boat ramps. The camera systems are not described here in detail as each system is configured to suit the local situation. Essentially each system consists of a camera which transmits images to a PC, which time stamps, and saves, and then transmits these images in batches to a NIWA site server via broadband internet. Some issues to be considered when establishing a web camera system are: the location and availability of structures which provide a good view of each ramp (e.g. power poles, street lights, private buildings); how power is provided to the web camera and associated PC/modem (national power grid, private power supply, intermittent street light power or solar power coupled with batteries and charger); how the image data is transmitted to the associated PC (wireless link or cable); and where to locate the PC and modem within reception range of the wireless camera while having access to internet broadband. Broadband is required because images are collected every minute, which means that the PC must be within approximately 5 km of a Telecom exchange. Teething problems occurring after camera installation and sporadic events, such as lightning strikes on overhead power lines causing power surges, have resulted in occasional system failures resulting in a loss of data. With time, camera systems tend to become more reliable, as they are re-engineered to overcome inherent site specific shortcomings. Problems are usually detected quickly via an automated email alarm protocol, and remedied as quickly as possible. Some substantial delays have been experienced because of third parties, such as local councils, who have taken time to reinstate light poles that have been knocked down. There has also been an increasing incidence of radio interference degrading the quality of images that are transmitted from the camera to a nearby PC connected to the internet. This is thought to be due to a proliferation of communication devices transmitting on the 2.4 GHz frequency and this problem is best resolved by moving our systems to the less commonly used 5.8 GHz frequency.

Web cameras were first installed in the inner Hauraki Gulf in early 2004, overlooking public boat ramps at Takapuna and Half Moon Bay (Figure 1). A further four camera systems were installed in FMA 1 in 2005; two in East Northland (Waitangi and Parua Bay) and two in the Bay of Plenty (Sulphur Point and Whakatane). These six systems have provided a means of monitoring trends in boating effort an all three regions of FMA 1, although images have only been interpreted from a single camera in each region; at Waitangi in East Northland, at Takapuna in the Hauraki Gulf, and at Sulphur Point in the Bay of Plenty. The merits of continuing to maintain secondary systems in each region (respectively at Parua Bay, Half Moon Bay, and at Whakatane) was assessed as part of another programme (Hartill 2015).

Web camera systems have also been installed overlooking boat ramps on the west coast of the North Island (FMAs 8 and 9) as part of an assessment of the recreational snapper harvest in SNA 8 (Hartill et al. 2011). The west coast fishery is spatially disaggregated, and multiple cameras are required to monitor effort taking place in the large harbours to the north, on the open northern coast, and on the open coast to the south (Figure 1) which often experience very different weather regimes.

The first camera to be installed on the west coast was at Shelly Beach in the Kaipara harbour, in July 2006. Many of the boats observed were potentially used for commercial and not recreational fishing, and a second high resolution camera was subsequently installed to provide views of these boats from another angle. We can now more readily identify and discount commercial set net vessels given the presence of: large numbers of admiralty anchors, fish bins, nets, alkathene hoops over outboards, identification numbers painted on boats, and from the nature of the vehicles used to tow these boats.

A pair of systems was also installed at Raglan, in November 2009. One camera overlooks the boat ramp at Manu Bay, on the open coast, and another overlooks the entrance to Raglan Harbour. The field of view at this second camera is approximately 250 m wide and we have calculated that a vessel travelling at 20 knots can only travel about 150 m in a 15 second period. We are therefore reasonably confident that a vessel cannot pass unobserved during daylight hours, as this camera takes a picture every 15 seconds (instead of at the usual 60 second interval). The combined counts from these two cameras can be used to provide an index of the level of effort on the open coast that originates from the Raglan area.

A third west coast camera was installed at New Plymouth in FMA 8, in December 2006. The initial performance of this camera system was not satisfactory, and several irresolvable issues led to the repositioning of this camera in September 2010. The two main problems encountered initially were a faulty gimbal mount that let the camera swing in strong winds and bad sun strike in late summer at the end of the day, which coincided with the peak time at which boats return to this ramp. The camera has now been repositioned across the water to the south of the ramp, and usable imagery has been collected almost continuously since this change has been made.

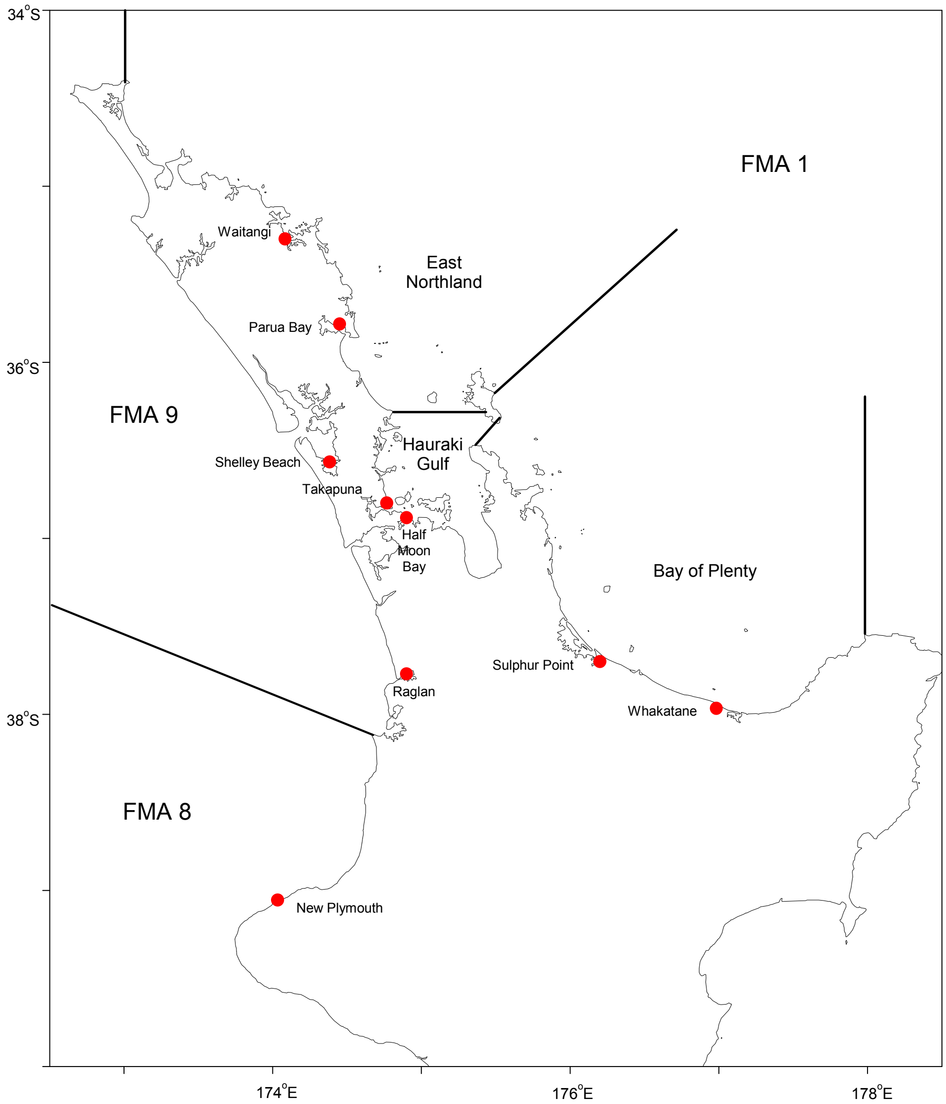


Figure 1: Locations of boat ramps where web cameras are installed in FMAs 1, 8 and 9.

<u>Subsampling image data</u>

Each camera system collects approximately half a million images per year, and the effort required to manually interpret all of the images collected at all ramps is considerable. Images are therefore interpreted from 60 days per fishing year only, which were preselected according to a stratified random temporal design. Days occurring within each fishing year were stratified by season (summer being 1 October to 30 April, and winter being 1 May to 30 September) and day type (midweek versus weekend and public holiday days). The decision to sample just 60 days per fishing year was based on an optimisation analysis of daily traffic counts derived from continuous footage of four FMA 1 ramps, collected over 349 days between 25 December 2004 and 24 December 2005 (Hartill et al. 2007). Days were randomly selected from each temporal stratum (by season/day type) in the first year of the time series (2004–05), and corresponding days were sampled in all of the following years, to ensure consistency with the social calendar. If, for example, one of the summer weekend/public holiday sample days selected in the first year fell on Good Friday, then images from Good Friday would be read in all subsequent years.

The total number of boats returning to each ramp within each seasonal/day-type stratum is the product of the average level of traffic on sampled days and the inverse of the sampling intensity for that stratum (Table 1). Sampling intensities for any given temporal stratum can vary from year-to-year as most public holidays such as Waitangi Day and ANZAC Day do not fall on the same day of the week in consecutive years. Further, normal working days that are bracketed by a public holiday and a weekend day are often popular choices for annual leave, and levels of traffic on these days are often more similar to those seen on weekends and public holidays.

Table 1: Temporal sampling design and the resulting intensity of sampling effort. The number of days within each temporal stratum differs from year-to-year depending on when public holidays fall and whether neighbouring days might be treated as an extended weekend break.

Season	Day type	Sampled days	All days	Sampling intensity
Summer	Mid-week	20	134 – 141	14.2% – 14.9 %
	Weekend/PH	24	71 – 78	30.8% – 33.8%
Winter	Mid-week	8	108 – 110	7.3% – 7.4%
	Weekend/PH	8	43 – 45	17.8% – 18.6%

Accounting for sample data loss due to system outages

Web camera systems sometimes fail for a wide range of unforeseeable reasons such as: cars knocking over light poles on which cameras are mounted, lightning strikes taking out power grids, internet outages, equipment failure, and intentional or unintentional human interference. These outages are regarded as random events as they are unlikely to be related to levels of fishing effort occurring at the time the outage occurred. Nonetheless, in a couple of cases data were not available for a significant proportion of a given season; e.g. at Takapuna in the summer of 2008–09, and at Waitangi in the winter of the same year. In these instances web imagery was only available for the end of the summer and the beginning of the winter, respectively, and the temporal coverage of the remaining data was not considered sufficiently representative to provide an unbiased estimate of the average daily level of traffic crossing these ramps, within the affected seasonal strata.

There appears to be, however, a reasonable degree of correlation between relative levels of effort across the three regions of FMA 1 (see Table 2). The degree of correlation seen here is similar to that found between the same boat ramps in 2004–05, when data were available for 349 of the 365 days between 25 December 2004 and 24 December 2005 (which ranged from 0.776 between Waitangi and Sulphur Point and 0.881 between Takapuna and Sulphur point) (Hartill et al. 2007).These levels of correlation are consistently high enough to suggest that meaningful predictions of effort can be made for one ramp on a day when an outage occurs, based on counts made at the other two ramps where the web camera systems were both fully operational on the same day. Generalised Linear Models were therefore used to predict levels of traffic for the 89 instances where a system outage was experienced on a preselected survey day by one of the three ramps considered here (out of a combined sample size of 1308 survey days falling between 1 April 2005 and 30 September 2012 across these three ramps).

Separate models were generated for each region, to determine the relationship between daily traffic counts at each ramp relative to those observed at the other two ramps given the fishing year, season, and day type in which these observations were made. Counts from the other two ramps were square root transformed to produce a more even spread of observations along the predicted space, and in doing so to reduce the leverage of extreme observations on the fit to the model. These counts were fitted as third order polynomials to allow for any non-linearity in their relationship with those of the response ramp. Ramp:year interaction terms were also offered to each model, to allow for the fact that the relationship between levels of traffic at each ramp can change over time. Each model was fitted in a stepwise manner to determine whether each variable should be selected, and the order in which those variables should be fitted (see Appendices 1, 2, and 3 for model selection statistics). These generalised models were then used to predict missing observations (and associated estimates of error for these estimates) when counts were available from two ramps on those days when an outage occurred at the third.

Although this model based method can be used to provide predictions of effort when counts are available from highly correlated alternative ramps in the same FMA, this approach was not used to provide predictions for outage affected days at Takapuna and Waitangi during mid to late November in 2012. This is because the outages at these ramps coincided, and the traffic levels at the remaining FMA 1 ramp (at Sulphur Point) were suppressed due to reduced fishing effort following the nearby grounding of the M.V. *Rena*, on the 5th of October 2012. The number of days sampled during the summer of 2011–12 at Takapuna and Waitangi were consequently lower than in previous years, and the loss of counts on these days were assumed to be random with respect to fishing effort.

Regression based predictions were also used to extend the time series at Takapuna (in the Hauraki Gulf) back to the beginning of the 2004–05 fishing year, based on data collected nearby at Half Moon Bay during this fishing year (see Hartill et al. 2010).

Levels of correlation across the three ramps in FMAs 8 and 9 were too low to support the use of the GLM based approach used in FMA 1. This means that system outages that coincide with preselected sample days reduce the number of observations available to inform any index of effort, and potentially, the extent to which that index describes the true level of fishing taking place throughout an affected temporal stratum.

Separate indices were calculated for each region of FMA 1, and in FMAs 8 and 9, based on the counts available from the ramp selected from that region. Daily counts from sampled days were averaged for each seasonal/day-type stratum, and these averages were scaled by the number of days occurring within each stratum to provide an estimate of the number of boats that returned to the ramp on those days. These stratum specific estimates of traffic volumes were then combined to produce an estimate of the number of boats that had returned to a given ramp during each fishing year or a season within each fishing year.

A two stage bootstrapping procedure was used to estimate variances. Daily counts were selected with replacement from each temporal stratum, and these counts were averaged and combined in the manner described above. When a sample day was selected for which the boat count was predicted rather than observed, the variance associated with this estimate (which was derived from the Generalised Additive Model) was used to generate a random normal deviate, which was added to the predicted count for that day. Standard error estimates were calculated from 1000 bootstrap estimates generated for each stratum.

Indices of effort were also calculated for the summer and winter seasons of each fishing year. These indices are actually estimates of the number of boats returning each fishing year to the ramp of interest, but it is assumed that the relative trends observed at this ramp broadly would reflect those occurring at other ramps within the same region.

3. RESULTS

FMA 1

The three primary web camera systems in FMA 1 were fully functional on most, but not all of the survey days preselected for the 2009–10, 2010–11, and 2011–12 fishing years (Table 2). At Waitangi protracted outages were experienced during the summers of 2009–10 and 2011–12 and data were not available for occasional days at other times. The Takapuna system experienced occasional short term outages in 2009–10, but problems with battery recharging resulted in data loss for a six week period in late 2011. Only the system at Sulphur Point was fully functional over the entire three year period.

Table 2: The number of days per fishing year for which 24 hours of web camera data were available and the number of sample days on which images were read relative to the intended survey design, for three key boat ramps in FMA 1. Numbers in bold italics denote temporal strata for which data were not available on some survey days because of system outages. Boxed areas denote the temporal strata for which indices of recreational effort have been calculated. Traffic volumes at a ramp on outage affected days were predicted from regressions of counts at the affected ramp against those at the other two ramps, from which data were available on the affected day. Regression based predictions were also used to extend the time series at Takapuna back to the beginning of the 2004–05 fishing year, based on data collected nearby at Half Moon Bay during this fishing year.

			Waitangi				Takapuna				Sulphur Point			
			Available days		Sample days		Available days		Sample days		Available days		Sample days	
Fyear	Season	Day type	Available	All	Sampled	All	Available	All	Sampled	All	Available	All	Sampled	All
2003–04	Summer	Midweek	–	143	–	20	48	143	–	20	–	143	–	20
		Weekend	–	70	–	24	20	70	–	24	–	70	–	24
	Winter	Midweek	–	109	–	8	109	109	–	8	–	109	–	8
		Weekend	–	44	–	8	44	44	–	8	–	44	–	8
	Total		–	366	–	60	221	366	–	60	–	366	–	60
2004–05	Summer	Midweek	***98***	***135***	***14***	***20***	***87***	***135***	***13***	***20***	***88***	***135***	***12***	***20***
		Weekend	***54***	***77***	***17***	***24***	***48***	***77***	***17***	***24***	***50***	***77***	***17***	***24***
	Winter	Midweek	109	109	8	8	***104***	***109***	8	8	***107***	***109***	8	8
		Weekend	44	44	8	8	***42***	***44***	8	8	44	44	8	8
	Total		305	365	47	60	281	365	45	60	289	365	45	60
2005–06	Summer	Midweek	135	134	20	20	***134***	***134***	20	20	134	134	20	20
		Weekend	77	78	24	24	***76***	***78***	24	24	***78***	***78***	24	24
	Winter	Midweek	110	110	8	8	110	110	8	8	110	110	8	8
		Weekend	43	43	8	8	43	43	8	8	43	43	8	8
	Total		365	365	58	60	363	365	60	60	364	365	60	60
2006–07	Summer	Midweek	135	135	20	20	135	135	20	20	135	135	20	20
		Weekend	77	77	24	24	***76***	***77***	***23***	***24***	77	77	24	24
	Winter	Midweek	109	109	8	8	109	109	8	8	109	109	8	8
		Weekend	44	44	8	8	44	44	8	8	44	44	8	8
	Total		365	365	60	60	365	365	59	60	365	365	60	60
2007–08	Summer	Midweek	***123***	***137***	***17***	***20***	***135***	***137***	***19***	***20***	138	137	20	20
		Weekend	***70***	***76***	***20***	***24***	***73***	***76***	24	24	75	76	24	24
	Winter	Midweek	***96***	***108***	***6***	***8***	***100***	***108***	***7***	***8***	***96***	***108***	***7***	***8***
		Weekend	***41***	***45***	***7***	***8***	***41***	***45***	***7***	***8***	***41***	***45***	***7***	***8***
	Total		330	366	50	60	349	366	57	60	350	366	58	60
2008–09	Summer	Midweek	140	140	20	20	***26***	***140***	***2***	***20***	140	140	20	20
		Weekend	72	72	24	24	***12***	***72***	***6***	***24***	72	72	24	24
	Winter	Midweek	***24***	***108***	***1***	***8***	108	108	8	8	108	108	8	8
		Weekend	***10***	***45***	***2***	***8***	45	45	8	8	45	45	8	8
	Total		246	365	47	60	191	365	24	60	365	365	60	60
2009–10	Summer	Midweek	***122***	***141***	***13***	***20***	141	141	20	20	141	141	20	20
		Weekend	***64***	***71***	***21***	***24***	***70***	***71***	***23***	***24***	71	71	24	24
	Winter	Midweek	***106***	***108***	***6***	***8***	***98***	***108***	***7***	***8***	108	108	8	8
		Weekend	45	45	8	8	***39***	***45***	***5***	***8***	45	45	8	8
	Total		337	365	48	60	348	365	55	60	365	365	60	60
2010–11	Summer	Midweek	140	140	20	20	140	140	20	20	***142***	***140***	***19***	***20***
		Weekend	72	72	24	24	72	72	24	24	***65***	***72***	***23***	***24***
	Winter	Midweek	***104***	***110***	***7***	***8***	110	110	8	8	110	110	8	8
		Weekend	***41***	***43***	***8***	***8***	43	43	8	8	43	43	8	8
	Total		357	365	59	60	365	365	60	60	360	365	58	60
2011–12	Summer	midweek	***91***	***135***	***16***	***20***	***97***	***135***	***18***	***20***	135	135	20	20
		Weekend	***59***	***78***	***22***	***24***	***60***	***78***	***23***	***24***	78	78	24	24
	Winter	midweek	***108***	***108***	***7***	***8***	***103***	***108***	***7***	***8***	108	108	8	8
		Weekend	***45***	***45***	***7***	***8***	***42***	***45***	***7***	***8***	45	45	8	8
	Total		303	366	47	60	302	366	49	60	366	366	60	60

There was usually a high degree of correlation between counts from pairs of ramps in most fishing years (Figure 2), but these relationships were weaker in 2011–12 because protracted outages were experienced at Waitangi and Takapuna, and because traffic at Sulphur Point during the first three months of this fishing year was noticeably suppressed following the grounding of the M.V. *Rena*.

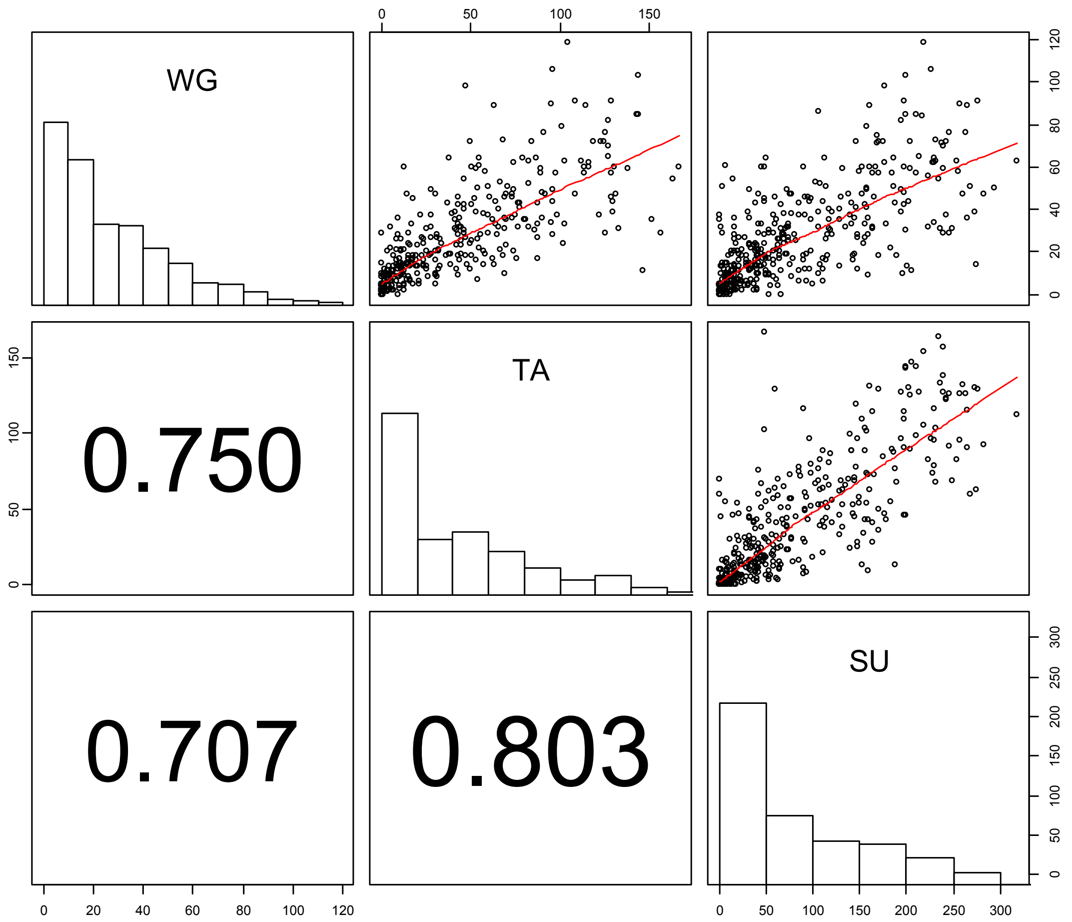


Figure 2: Counts of the number of trailer boats returning to three ramps in FMA 1 (Waitangi in East Northland – WA, Takapuna in the Hauraki Gulf – TA, and Sulphur Point in the Bay of Plenty – SU) regressed against numbers of boats observed at the other two ramps on each survey day. Pearson correlation coefficients are given in the bottom left panels.

The Generalised Linear Models used to predict the levels of traffic at ramps on outage affected days appear to give meaningful estimates given the degree of correlation between observed and fitted counts for those days when the response ramp system was fully operational (Waitangi, $R^{2=}$0.693; Takapuna, 0.777; and Sulphur Point 0.774; see diagnostic plots given in Appendix 1). The peaks and troughs seen in time series of actual and predicted daily count estimates for each ramp show a strong resemblance (Figure 3). The predicted values are only used for those days when actual counts are not available, which are seen as periods when only dashed lines are plotted in Figure 3. Neither observed nor fitted counts are available for Waitangi and Takapuna for a period in October and November 2011 because of coinciding outages at these ramps and because levels of traffic at the remaining Sulphur Point ramp would be influenced by issues relating to the grounding of the M.V. *Rena*.

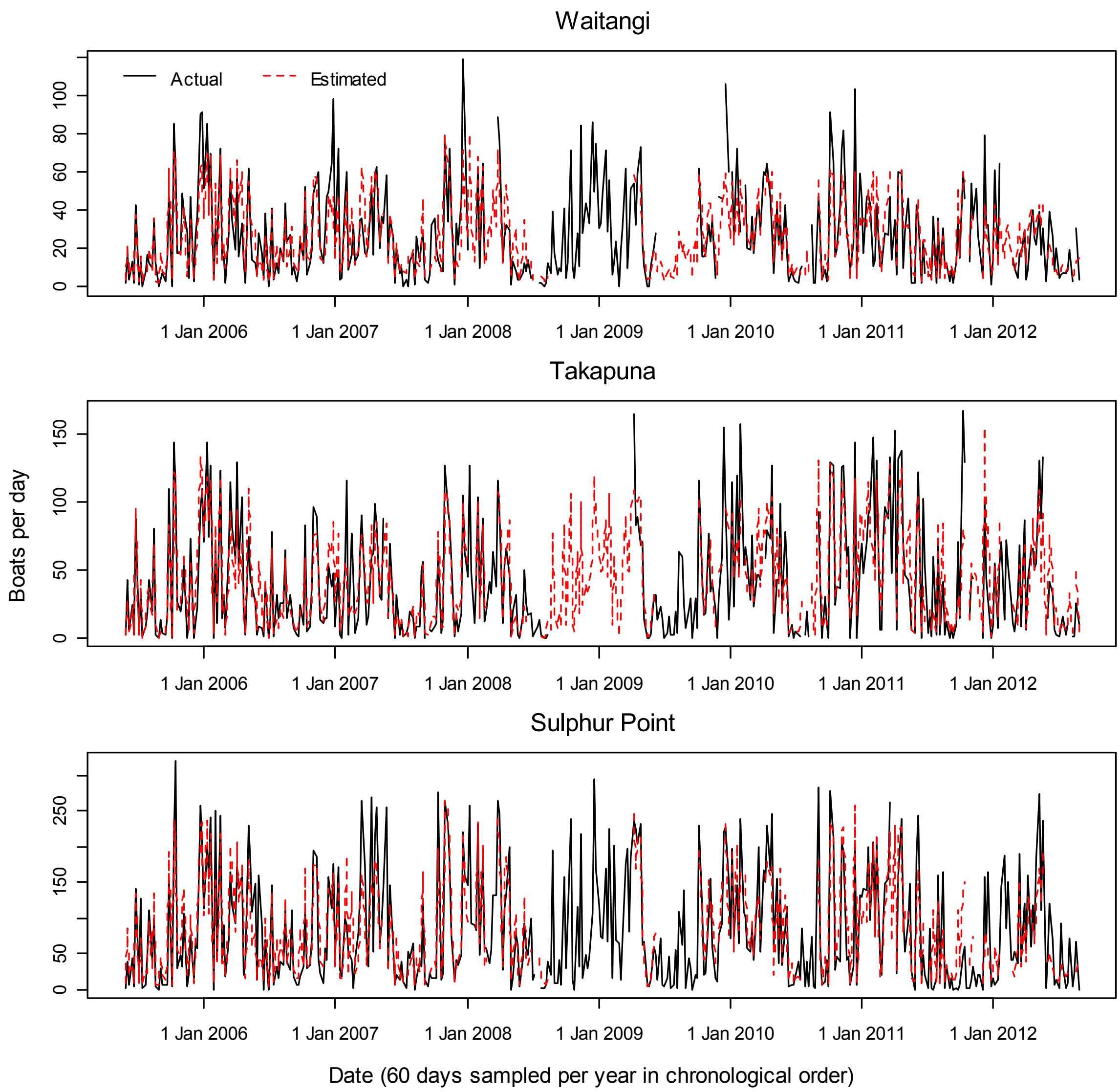


Figure 3: Daily counts of boats returning to three boat ramps in FMA 1. Solid lines denote actual counts and dashed lines denote counts for the same ramp which are predicted from a model based on counts made at the other two ramps on the same day, given the temporal strata within which these days fall. The daily counts are presented here in chronological order, but it should be noted that these counts are based on a 60 day subsample of all possible days, which were selected according to a stratified random design.

Most of the data used to generate indices of effort were counts of boats observed returning to each ramp on each survey day, but in some cases it was necessary to use predicted counts for those days when outages had occurred, as discussed above.

Similar numbers of trailer boats returned to the East Northland ramp at Waitangi between 2005–06 and 2010–11, followed by a drop in effort during the summer of 2011–12 and a slight increase during the following winter (Figure 4). Indices of annual effort calculated for Takapuna (in the Hauraki Gulf) and Sulphur Point (Bay of Plenty) were more variable over time. Effort in both these regions peaked in 2010–11 and then declined markedly in 2011–12, both annually and seasonally.

Levels of effort at all three regional ramps have therefore fluctuated over time, but there is no long term trend over this period (Figure 5).

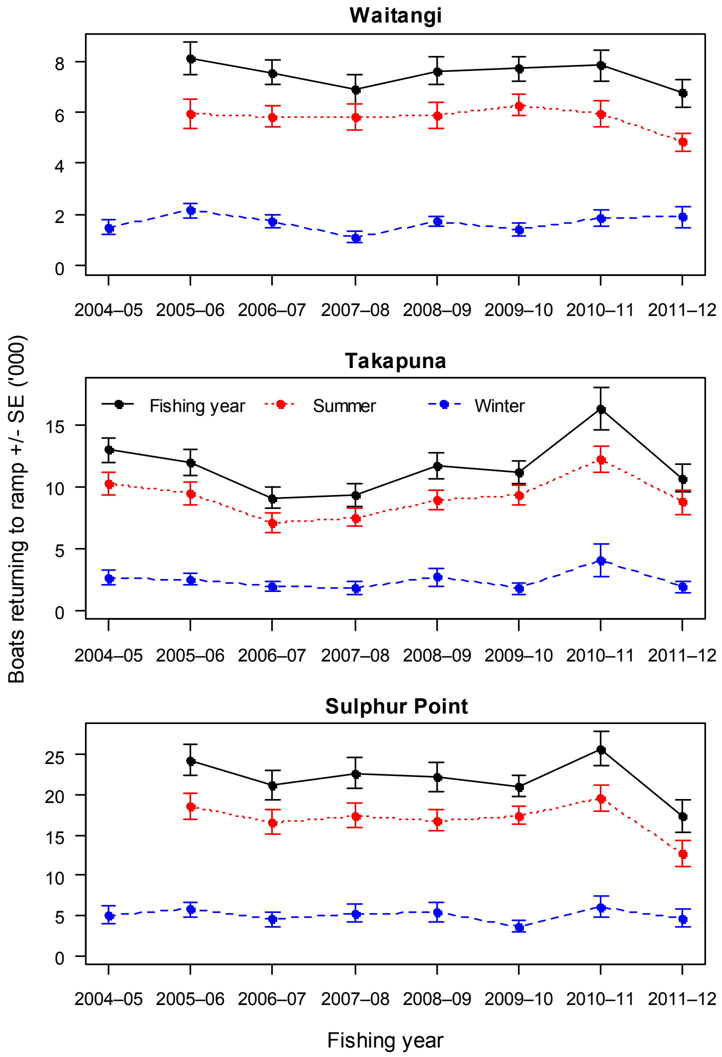


Figure 4: Indices of recreational effort for three regions of FMA 1 based on imagery taken at a single ramp within each of those regions on a subsample of 60 days per fishing year.

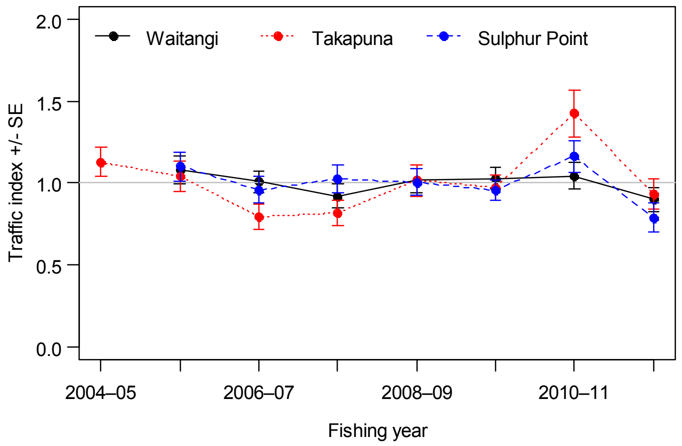


Figure 5: Comparison of relative indices of annual effort for the three regions of FMA 1. Indices for all three regions are averaged to 1.0 for the period 2005–06 to 2011–12, as images of the ramps at Waitangi and Sulphur Point are not available for the summer of 2004–05.

FMAs 8 and 9

The web camera systems in FMA 9 have provided almost continuous coverage of traffic at Shelly Beach since the summer of 2006–07 and at Raglan since the summer of 2010–11 (Table 3). Images provided by the New Plymouth system in FMA 8 were initially unreadable at times (sun strike or an unstable camera mounting) but the system has provided almost continual and reliable coverage since the summer of 2009–10.

Table 3: The number of days per fishing year for which 24 hours of web camera data were available and the number of sample days on which images were read relative to the intended survey design, at Shelly Beach in the Kaipara Harbour, at a pair of sites at Raglan, and at New Plymouth. Numbers in bold italics denote temporal strata for which data were not available on some survey days because of system outages. Boxed areas denote the temporal strata for which indices of recreational effort have been calculated.

			Shelly Beach				Raglan				New Plymouth			
			Available days		Sample days		Available days		Sample days		Available days		Sample days	
Fyear	Season	Day type	Available	All	Sampled	All	Available	All	Sampled	All	Available	All	Sampled	All
2005–06	Summer	Midweek	–	135	–	–					–	135	–	20
		Weekend	–	77	–	–					–	77	–	24
	Winter	Midweek	55	110	3	3					–	110	–	8
		Weekend	22	43	4	4					–	43	–	8
	Total		77	365	7	7					–	365	–	60
2006–07	Summer	Midweek	135	135	20	20					***70***	***135***	***7***	***20***
		Weekend	77	77	24	24					***47***	***77***	***13***	***24***
	Winter	Midweek	109	109	8	8					***103***	***109***	***7***	***8***
		Weekend	44	44	8	8					***41***	***44***	***7***	***8***
	Total		365	365	60	60					261	365	34	60
2007–08	Summer	Midweek	***137***	***137***	***19***	***20***					***125***	***137***	***17***	***20***
		Weekend	76	76	24	24					***68***	***76***	***22***	***24***
	Winter	Midweek	108	108	8	8					***91***	***108***	***5***	***8***
		Weekend	45	45	8	8					***37***	***45***	***5***	***8***
	Total		365	366	59	60					321	366	49	60
2008–09	Summer	Midweek	***139***	***140***	***19***	***20***					***133***	***140***	***17***	***20***
		Weekend	72	72	24	24					***69***	***72***	***21***	***24***
	Winter	Midweek	108	108	8	8					***40***	***108***	***3***	***8***
		Weekend	45	45	8	8					***15***	***45***	***2***	***8***
	Total		364	365	59	60					257	365	43	60
2009–10	Summer	Midweek	141	141	20	20	***67***	***75***	***8***	***10***	***140***	***141***	***19***	***20***
		Weekend	***70***	***71***	***23***	***24***	***31***	***34***	***11***	***12***	***68***	***71***	***21***	***24***
	Winter	Midweek	108	108	8	8	***107***	***108***	***6***	***8***	***107***	***108***	***7***	***8***
		Weekend	45	45	8	8	***44***	***45***	***7***	***8***	***43***	***45***	***7***	***8***
	Total		364	365	59	60	250	262	32	38	358	365	56	60
2010–11	Summer	Midweek	***135***	***140***	***17***	***20***	***138***	***140***	***18***	***20***	140	140	20	20
		Weekend	***60***	***72***	***19***	***24***	***63***	***72***	***23***	***24***	72	72	24	24
	Winter	Midweek	106	110	8	8	110	110	8	8	110	110	8	8
		Weekend	***40***	***43***	***6***	***8***	43	43	8	8	43	43	8	8
	Total		341	365	50	60	354	365	57	60	365	365	60	60
2011–12	Summer	midweek	***133***	***135***	20	20	***134***	***135***	***19***	***20***	***133***	***135***	20	20
		Weekend	***72***	***78***	***22***	***24***	***77***	***78***	***23***	***24***	***72***	***78***	***22***	***24***
	Winter	midweek	108	108	8	8	***101***	***108***	8	8	***106***	***108***	8	8
		Weekend	45	45	8	8	***41***	***45***	8	8	***42***	***45***	8	8
	Total		358	366	58	60	353	366	58	60	353	366	58	60

The regression based methods used to predict traffic at FMA 1 ramps on days when images are not available given concurrent counts observed at other ramps, cannot be used to provide similar predictions for FMA 8 and 9 ramps, because of the low degree of correlation between any pair of ramps (Figure 6). This is because fishing conditions (i.e. weather and sea state) can vary considerably between these west coast ramps on any given day.

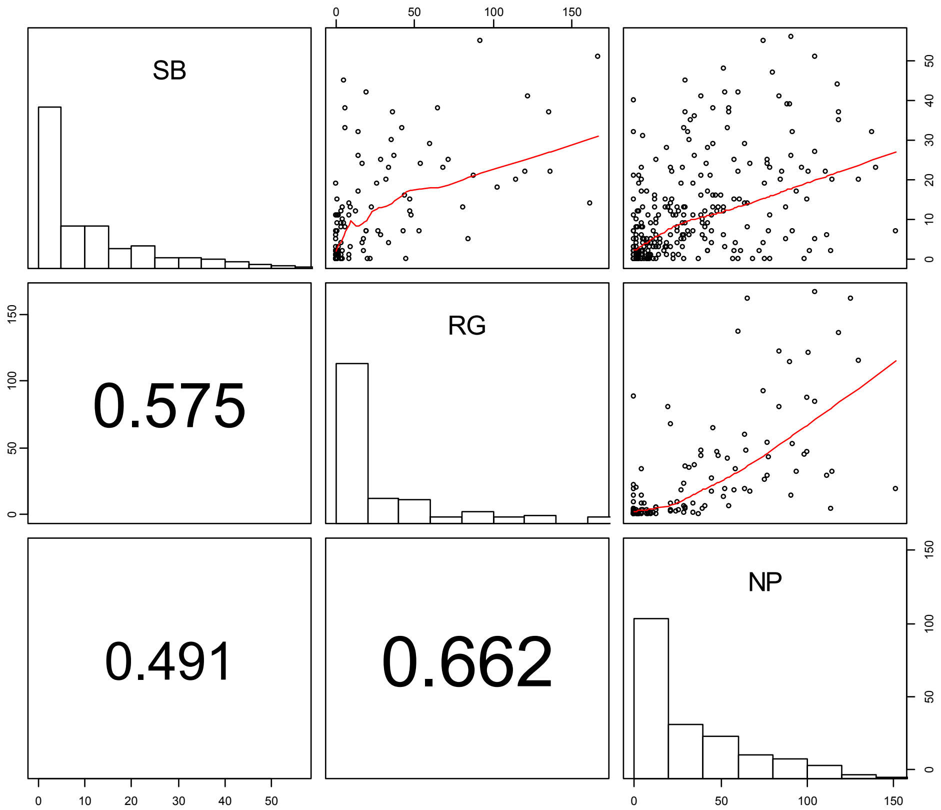


Figure 6: Counts of the number of trailer boats returning to two ramps in FMA 9 (Shelly Beach in the Kaipara Harbour – SB, and at Manu Bay/Raglan Harbour entrance on the open coast – RG) and at New Plymouth (NP) in FMA 9, regressed against numbers of boats observed at the other two ramps on each survey day. Pearson correlation coefficients are given in the bottom left panels.

There are, therefore, two alternatives available when generating indices of effort in FMAs 8 and 9, based on the available data. The first option is to just use boat counts on the survey days for which a full 1440 minute-by-minute images are available, and assume that levels of traffic on these days provide a sufficient and representative measure of the average daily level of effort taking place on all days within each temporal stratum. The second option is to read images from additional alternative days that fall as close as possible within a given temporal stratum. Although the second approach should be valid when short term outages occur, long term outages are still problematic. At this stage we have generated indices of effort for the FMA 8 and 9 ramps based on the preselected days for which readable images are fully available, as described in Table 3.

Trends in effort at the two FMA 9 sites (Shelly Beach and Raglan) appear to be potentially similar, although traffic count data are only available from Raglan since the winter of 2009–10, and differences in trends in effort at the two ramps may become more apparent over time (Figures 7 and 8). Ramp traffic at Shelly Beach peaked during the 2010–11 fishing year, followed by far lower traffic levels in 2011–12.

Traffic rates at New Plymouth in FMA 8 were also high in 2010–11, relative to those observed in 2009–10 and 2011–12, but traffic was equally busy in 2006–07.

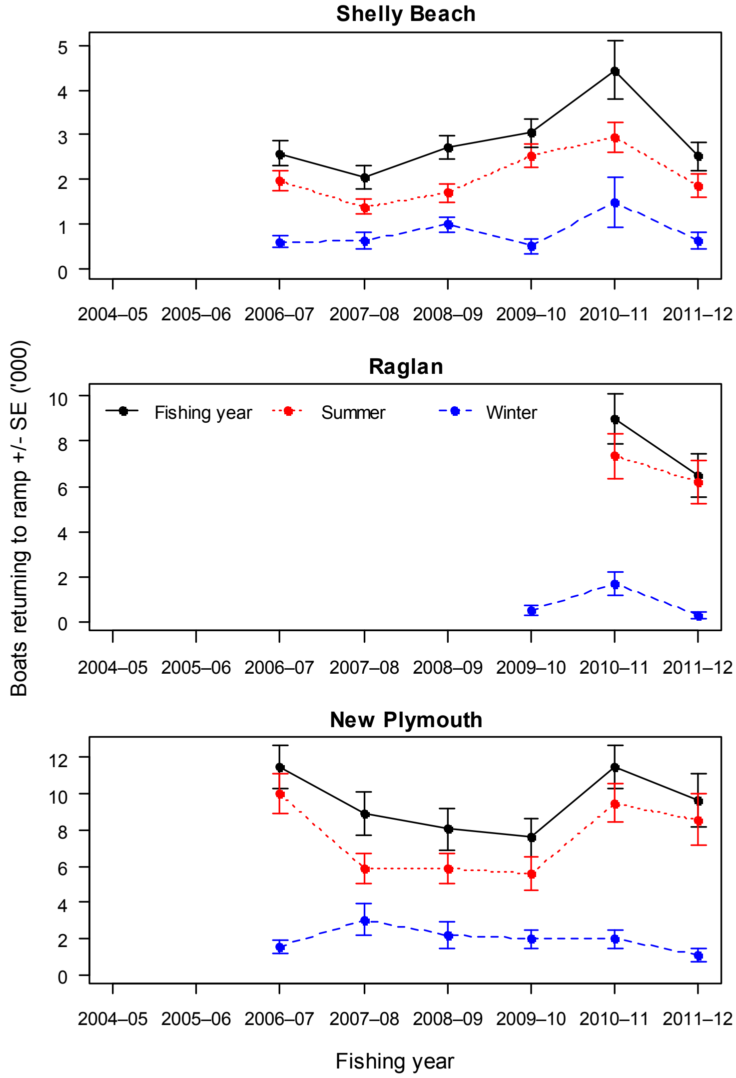


Figure 7: Indices of recreational effort at Shelly Beach in FMA 9 and at New Plymouth in FMA 8 based on imagery taken on a subsample of 60 days per fishing year.

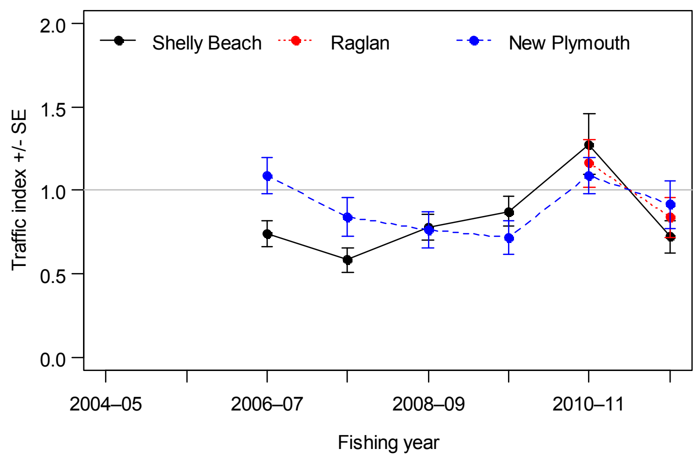


Figure 8: Comparison of relative indices of annual effort for the three ramps in FMAs 8 and 9. Indices for all three regions are averaged to 1.0 for the period 2010–11 to 2011–12 only, as images for Raglan have only been available since the winter of 2009–10.

4. DISCUSSION

Web cameras provide a cost effective means of monitoring trends in the number of boats returning to boat ramps over the long term, and these trends are assumed to be broadly representative of those experienced at other ramps in the same region/FMA. The level of correlation between daily traffic counts across three regions of FMA 1 is high, and this suggests that trends in effort at ramps within each region should also be correlated to a reasonable degree. The spatial resolution at which trends in effort are monitored is an important consideration as levels of regional effort can vary in response to localised changes in human and fish population density. Within FMA 1 the decision has been made to monitor trends in effort for three separate regions: East Northland, the Hauraki Gulf, and the Bay of Plenty. Although web camera systems are currently installed overlooking two ramps in each of these regions, the rationale for continuing to maintain more than one system in each region has been evaluated as part of another programme (Hartill 2015).

On the west coast of the North Island (FMAs 8 and 9) spatial trends in fishing effort can differ to a far greater degree, partially because the harbour fisheries in the north are far more sheltered than waters off the open coast, and partially because wind and swell conditions can vary considerably from north to south. The spatial distribution of fishing effort on this coast is patchy and mostly centred around population centres. There are far fewer access points on this coast, and consequently a small number of ramps account for most of the boat based effort occurring on the west coast. Results from an aerial access survey of the SNA 8 fishery in 2006–07 suggest that 44% of the recreational snapper harvest was taken on the open northern coast, 12% on the open coast off Taranaki, 11% off the coast to the south of Taranaki, 28% was taken from the Hokianga and Kaipara Harbours, with the remaining 5 % taken from the Manukau, Raglan, and Kawhia Harbours (5%) (Hartill et al. 2011). These results suggest that the web cameras at Shelly Beach, Raglan, and New Plymouth, can be used to monitor trends in most, but not all of the boat based activity on the west coast of the North Island. Although the southern open coast fishery accounted for only 11% of the recreational SNA 8 harvest, the relative level of effort in the Kapiti Island area is likely to be much higher than this estimate suggests, as snapper only account for a fraction of the overall recreational harvest taken in this area.

Occasionally events such as the grounding of the M.V. *Rena* in October 2011 will influence localised levels of fishing effort, over at least the short term, and this possibility should always be considered when interpreting indices of effort. The M.V. *Rena* grounding is an extreme example of an atypical event, as the closure of ramps and large areas of coastal waters to recreational fishing is very unusual. The short term effect of this event would have been partially offset by a displacement of effort to other ramps and waters in the Bay of Plenty, which was evident in aerial surveys of the recreational fishery at that time. This displacement of effort would not have been detected by the camera at Sulphur Point and this region's effort index may therefore overestimate any decline in effort at that time.

Although trends in effort vary across regions and FMAs to some degree, after only 6–7 years a common pattern is still evident. Levels of effort declined at all FMA 1 sites after 2005–06 and after 2006–07 in FMAs 8 and 9. Effort then peaked in 2010–11 followed by a marked decline in 2011–12. The degree of decline in effort between 2010–11 and 2011–12 does, however, vary considerably between regions; ranging from 16% to 39% in FMA 1 and from 16% to 47% in FMA8/9. Recreational effort can therefore still vary considerably between years, to differing extents in each region, but no long term trend in effort is evident at this stage.

Web camera based indices of recreational effort, coupled with harvest estimates provided by surveys of New Zealand's recreational fisheries in 2011–12 provide some insight into how levels of recreational harvesting may have changed in recent years. The trends seen at all six ramps suggest that harvest estimates derived from surveys of New Zealand's recreational fisheries in 2011–12 were obtained in a year when levels of fishing effort were suppressed during the busier summer months. Recreational snapper catch rates in FMA 1 have also increased in recent years (Hartill 2012). This means that projecting these harvest estimates into the future potentially underestimates the impact that some recreational fisheries will have in coming years.

The indices of effort provided here do not, however, fully describe trends in recreational catch, as an unknown proportion of the boats observed on camera will have been used for purposes other than fishing. Further, trends in fishing effort only partially describe trends in catch, as the catch rates experienced by observed boats will change over time, and catch rate information cannot be obtained from web camera imagery. Creel survey data were intentionally collected on web camera survey days for the first time in 2011–12 as part of MAF201107, and similar data were collected over the next two years as part of MAF201202. These data will ultimately be used to translate indices of boat ramp traffic (such as those presented here) into indices of recreational fishing effort, and then into indices of recreational harvest.

5. MANAGEMENT IMPLICATIONS

Trends in recreational boating effort presented here suggest that levels of recreational catch and effort have varied noticeably over the past 7 years in FMA 1, and the last 6 years in FMAs 8 and 9. Recent trends in effort observed at all ramps monitored by web cameras suggest that the harvest estimates derived from surveys of New Zealand's recreational fisheries in 2011–12 were obtained in a year when levels of fishing effort were suppressed during the busier summer months. Consequently, recreational harvests may be higher in future years if more favourable fishing conditions prevail and fishers continue to experience similar catch rates of commonly caught species

6. CONCLUSIONS

The key conclusions and findings of this research are that:

- indices of effort are presented for three regions of FMA 1 from 2004–05 to 2011–12, and for New Plymouth in FMA 8 and the Kaipara Harbour in FMA 9 from 2006–07 to 2011–12
- all of these regional indices are based on web camera counts of recreational boats returning to a single boat ramp on a random stratified subsample of 60 days per fishing year
- indices of effort in all three regions of FMA 1 are relatively flat, but peak in 2010–11, followed by a marked decline in effort in the following year
- a broadly similar trend is also seen in FMAs 8 and 9, but traffic volumes at New Plymouth were also high in the first year that this system was operational, in 2006–07, and
- that the trends seen at all six ramps suggest that harvest estimates derived from surveys of New Zealand's recreational fisheries in 2011–12 were obtained in a year when levels of fishing effort were suppressed during the busier summer months.

7. ACKNOWLEDGMENTS

This work was funded by the Ministry of Primary Industries project REC-2009/04. The authors wish to thank members of the Marine Amateur Fisheries Working Group for useful suggestions made during presentations of this and other web camera related programmes in the past. This report was reviewed in our internal review system by Darren Parsons.

8. REFERENCES

Hartill, B. (2012). Analyses to inform the management of the SNA 1 recreational fishery. Final Research Report for project MAF201199. 27 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B. (2015). Evaluation of web camera based monitoring of levels of recreational fishing effort in FMA 1. *New Zealand Fisheries Assessment Report 2015/22.* 13 p.

Hartill, B.; Payne, G.; Reddish, L.; Vaughan, M.; Spong, K.; Buckthought, D. (2007). Monitoring recreational fishing effort in QMA 1. Final Research Report for Ministry of Fisheries Project REC2005/06. 17 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hartill, B.; Rush, N.; Payne, G. (2010). Web camera based indices of recreational fishing effort in QMA 1 and QMA 8. Final Research Report for Ministry of Fisheries Project REC2007/02. 24 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

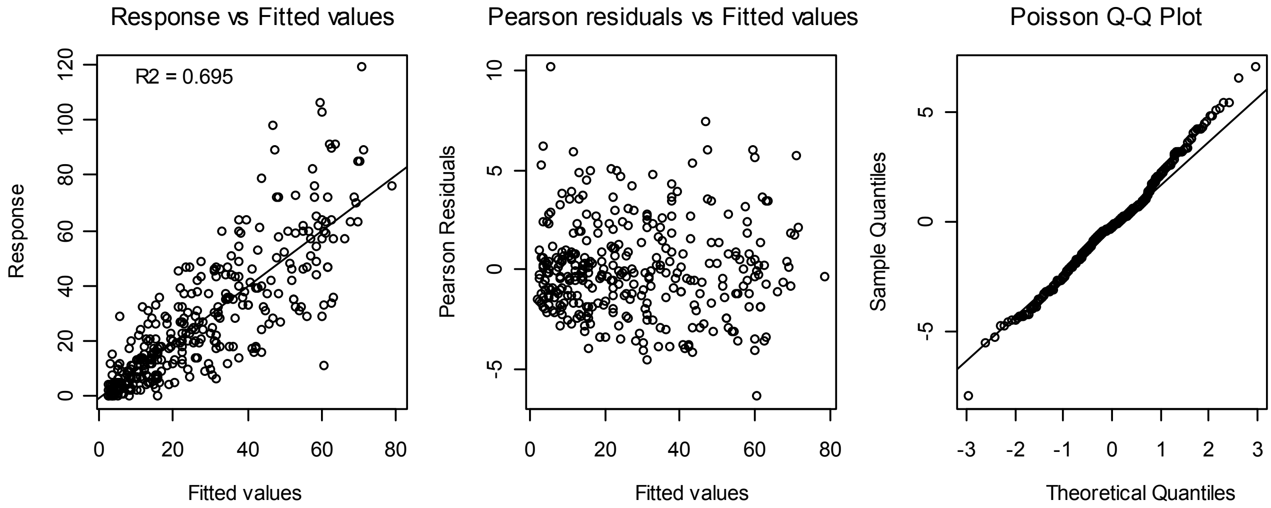
Hartill, B.; Vaughan, M.; Rush, N. (2011). Recreational harvest estimate for SNA 8 in 2006–07. *New Zealand Fisheries Assessment Report 2011/51*. 48 p.

APPENDIX 1: Diagnostics for GLMs of FMA 1 daily traffic count data

Appendix 1a: Order in which explanatory variables are fitted to a model of daily boat traffic volumes at the Waitangi boat ramp in East Northland. The additional deviance explained by the sequential addition of each variable and the probability that the addition of that variable improves the explanatory power of the model is also given.

Variable	% Deviance explained	P(>|Chi|)	
sqrt(TA)	64.86%	< 2.2e-16	***
Fishing year	2.10%	7.2581E-26	***
Day type	2.50%	1.209E-36	***
Season	1.46%	4.7972E-22	***
Fyear:sqrt(SU)	1.01%	6.6417E-11	***
Fyear:sqrt(TA)	1.09%	1.6012E-12	***

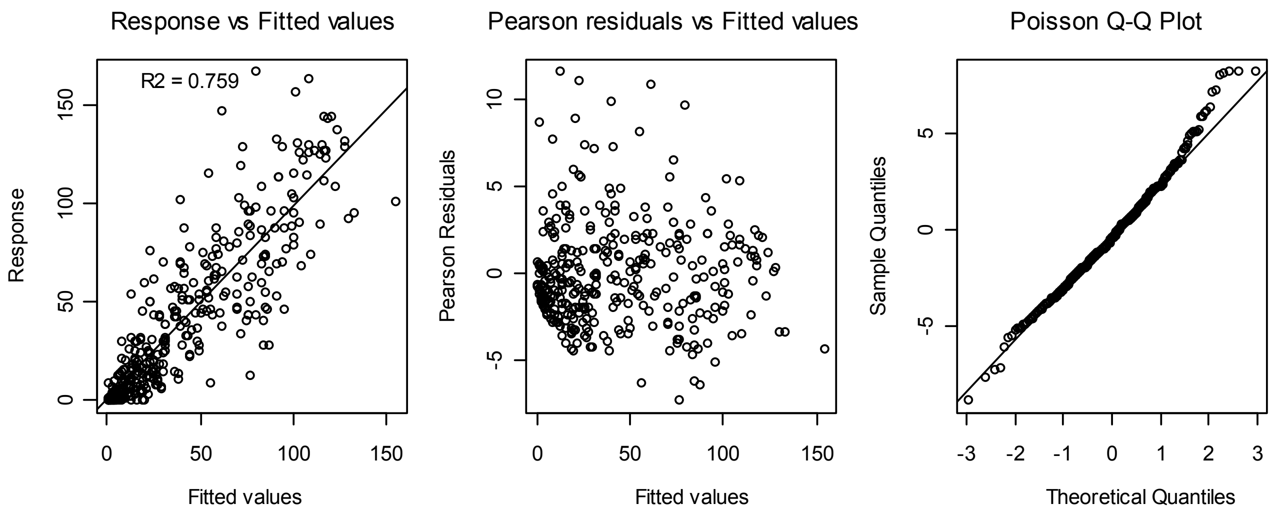
Diagnostic plots of the relationship between daily counts of boats returning to the Waitangi boat ramp relative to daily counts predicted from a model based on the variables given above [left panel]; residuals plotted against the daily counts predicted by the model [middle panel]; a Q–Q plot of these residuals.



Appendix 1b: Order in which explanatory variables are fitted to a model of daily boat traffic volumes at the Takapuna boat ramp in the Hauraki Gulf. The additional deviance explained by the sequential addition of each variable and the probability that the addition of that variable improves the explanatory power of the model is also given.

Variable	% Deviance explained	P(>|Chi|)	
sqrt(SU)	64.16%	< 2.2e-16	***
sqrt(WG)	11.98%	< 2.2e-16	***
Fishing year	2.22%	4.1724E-59	***
Season	0.25%	1.2239E-08	***
Fyear:sqrt(SU)	0.51%	8.0905E-12	***
Fyear:sqrt(WG)	1.18%	2.8859E-30	***

Diagnostic plots of the relationship between daily counts of boats returning to the Takapuna boat ramp relative to daily counts predicted from a model based on the variables given above [left panel]; residuals plotted against the daily counts predicted by the model [middle panel]; a Q–Q plot of these residuals.



APPENDIX 1: Continued

Appendix 1c: Order in which explanatory variables are fitted to a model of daily boat traffic volumes at the Sulphur Point boat ramp in the Bay of Plenty. The additional deviance explained by the sequential addition of each variable and the probability that the addition of that variable improves the explanatory power of the model is also given.

Variable	% Deviance explained	P(>|Chi|)	
sqrt(WG)	53.59%	< 2.2e-16	***
sqrt(TA)	16.37%	< 2.2e-16	***
Fishing year	1.35%	4.6476E-68	***
Daytype	3.04%	3.925E-165	***
Season	0.52%	1.2041E-29	***
Fyear:sqrt(WG)	0.95%	3.7847E-47	***
Fyear:sqrt(TA)	0.93%	7.9273E-46	***

Diagnostic plots of the relationship between daily counts of boats returning to the Sulphur Point boat ramp relative to daily counts predicted from a model based on the variables given above [left panel]; residuals plotted against the daily counts predicted by the model [middle panel]; a Q–Q plot of these residuals.