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Evaluation of web camera based monitoring of levels of recreational fishing effort in FMA 1

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

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.* 12 p.**

Web cameras have been used to monitor trends in recreational effort at key boat ramps in FMA 1 since 2005 and in FMAs 8 & 9 since 2006. Each web camera system takes minute-by minute time-stamped images 24 hours a day, and the resulting time series of images can be interpreted to provide a count of daily levels of traffic at a given ramp.

When the first web camera systems were established in 2005, their reliability and utility was uncertain, and the decision was made to install cameras overlooking two ramps in each region of FMA 1 (East Northland, the Hauraki Gulf, and the Bay of Plenty). Although indices of effort have since been generated from images provided by a primary ramp in each region, images collected at a secondary site in each region have been stored but not interpreted. The ongoing maintenance of these secondary web cameras is not without cost however, and the merits of maintaining each of these additional effort monitoring systems is evaluated here.

The only ramp independent source of information that we have on daily levels of recreational fishing effort in FMA 1 is that provided by aerial surveys of the fishery in 2004–05 and 2011–12. Aerial survey based counts of boats fishing at about mid-day are compared with web camera based counts of boats returning to the primary and secondary ramps in the same region, throughout the same days. These comparisons of aerial and web camera based counts provide three measures which can be used to evaluate whether web cameras should be maintained at more than one site in each region. These metrics were used to assess: whether web camera and aerial count data suggested similar changes in levels of regional fishing effort across the two years, whether capacity at each ramp became saturated on high effort days in either year, and the extent to which data from a second ramp improved the relationship between aerial and ramp based counts in each region.

In East Northland these metrics suggest that traffic count data provided by a single ramp at Waitangi should provide an adequate means of monitoring trends in recreational effort. There is evidence to suggest, however, that trends in effort at the alternative Parua Bay site do not match those of the wider East Northland fishery, which will lead to a misleading effort index over time. In the Hauraki Gulf, however, both camera systems should be maintained in the future, as each site has advantages over the other, and the level of recreational harvesting and effort in this region warrants the continued maintenance of two systems should either fail for some time. In the Bay of Plenty the system at Sulphur Point appears to provide a very reliable means of monitoring recreational effort that is consistent over time, whereas there appears to be little merit in continuing to maintaining a secondary system at Whakatane where the port is often closed because of a shifting bar at the harbour entrance.

Many of the vessels observed on camera will have been used for purposes other than fishing, and in 2011–12 creel survey interviews were also conducted at ramps overlooked by web cameras to provide data on the proportion of these boats that were used for fishing and on the catch rates of key species. These concurrent creel survey data were purposefully collected for the first time in 2011–12 so that the indices of boat traffic currently generated from web camera data can be translated into indices of fishing effort, and subsequently, into indices of recreational harvest, that are of more relevance to fisheries managers. Summary statistics describing data collected during these interviews are presented in this report. These data will be more fully analysed as part of another MPI research programme in the near future.

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 fishing effort 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.

A network of web cameras has been established overlooking key boat ramps around Northern New Zealand. Although web camera systems provide a means of monitoring trends in boat ramp traffic over time, further information is required to translate this information into the relative indices of recreational harvest ultimately required by fisheries managers. The additional sources of information required to make this translation are: data on the proportion of boats that are used for fishing (as some boats are used for other purposes), and on catch rates experienced by fishing parties. These additional data were collected for the first time in 2011–12 at boat ramps where web cameras were installed.

The reliability and utility of camera monitoring systems was uncertain when the first six web cameras were established in Fisheries Management Area 1 (FMA 1; Figure 1) in 2004–05. At that time the decision was made to install cameras overlooking two boat ramps in each FMA 1 region (East Northland, the Hauraki Gulf, and the Bay of Plenty; Figure 1). Recent analyses have shown that fishing effort levels are highly correlated across regions on a day to day basis (Hartill et al. 2007b) and only a single camera system may be required to monitor trends in effort in each region. Analyses are presented here which examine whether one or two cameras are required to monitor trends in fishing effort over the long term in each region of FMA 1.

The overall objectives of this research, within the Ministry for Primary Industries marine amateur fisheries research portfolio are to contribute to the design and implementation of an integrated amateur harvest estimation system through deriving methods to provide amateur harvest estimates which are comparable with future amateur harvest estimates. This project also contributes directly to monitoring changes in amateur fishing effort in QMA 1 and QMA 8.

The specific objectives of this research project were to optimise the number of web cameras required to monitor trends in amateur fishing effort in QMA 1, and to collect and use creel survey data to convert indices of amateur effort into indices of amateur catch.

2. METHODS

2.1 Web camera optimisation - overview

In 2004–05 a network of web cameras was established overlooking key boat ramps throughout FMA 1 (Figure 1). These cameras provide a potentially cost effective and reliable means of monitoring relative trends in recreational fishing effort, which is a key driver of levels of recreational harvest. Each system captures a time stamped image of the ramp every 60 seconds, and these are viewed as a time lapsed video to determine the number of trailer boats returning to the ramp throughout each 24 hour period. Regional indices of recreational effort have been generated from daily counts of boats returning to a single “primary” ramp in each region since 2005 (Hartill 2012). These indices are based on a random stratified sample of 60 days per fishing year, as a previous optimisation has shown that this level of sampling should result in a reasonable levels of precision (Hartill et al. 2007b).

Web camera systems were also established overlooking a “secondary” ramp in each region, and although these systems have also generated and stored time stamped images since early 2005, none of these images have previously been interpreted, as there has been no immediate need to do so.

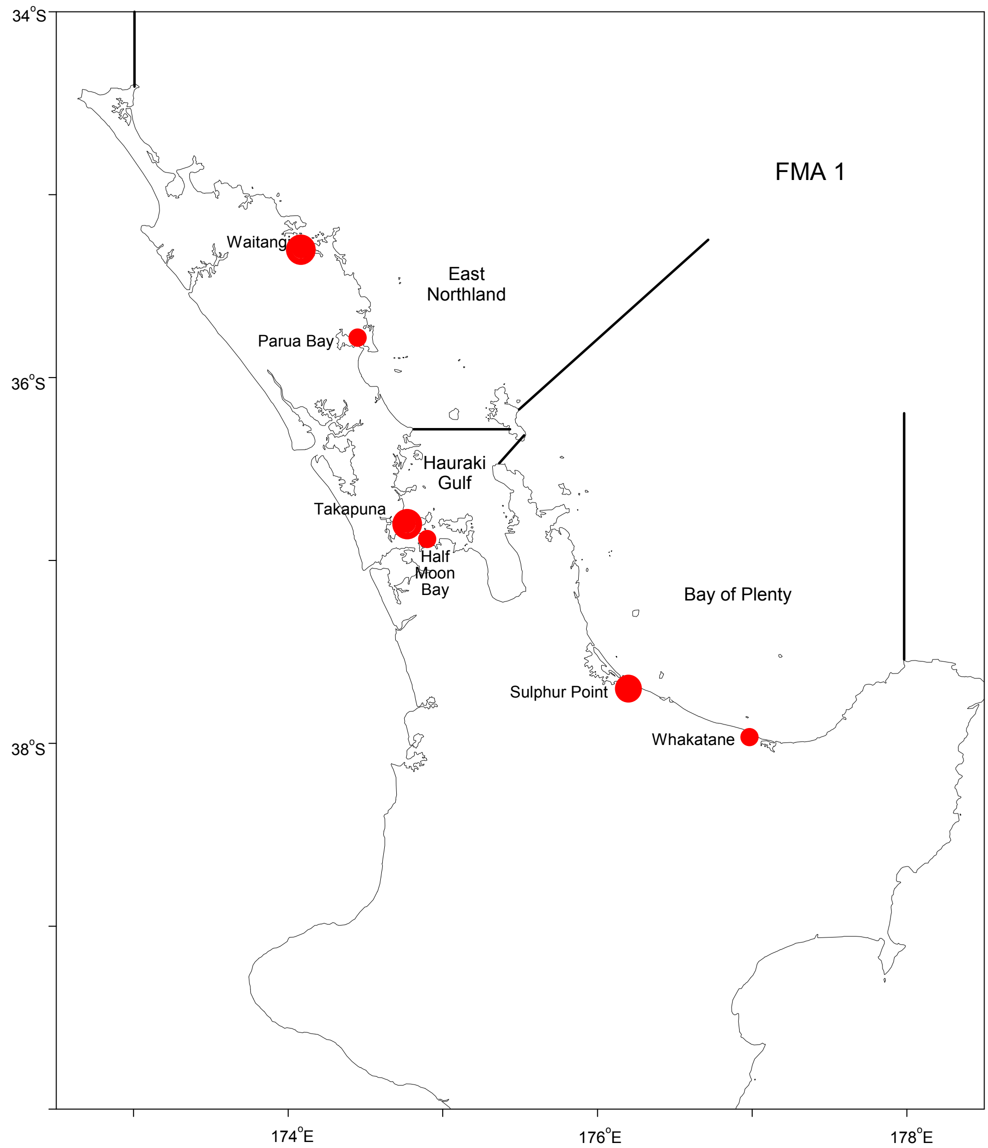

Figure 1: Locations of boat ramps where web cameras are installed in FMA 1. Indices of effort are currently derived from a single ramp in each region (primary ramps: Waitangi, Takapuna, and Sulphur Point; denoted by large symbols) and this report evaluates the possible additional benefit of interpreting images collected by a second ramp in each region (secondary ramps: Parua Bay, Half Moon Bay, and Whakatane; denoted by small symbols).

2.2 Ancillary data used to evaluate the utility of secondary cameras

Aerial surveys of recreational fishing boats provide a ramp independent source of data that can be used to evaluate how well primary and secondary cameras systems monitor changing levels of recreational fishing effort. Aerial surveys of FMA 1 were conducted in 2004–05, as part of a survey that provided recreational harvest estimates for the SNA 1 and KAH 1 fisheries (Hartill et al. 2007a), followed by a similar survey in 2011–12 (Hartill et al. 2013). These aerial surveys provide a snapshot of the number of boats actively involved in fishing throughout FMA 1, at around mid-day, whereas the web camera systems provide a count of all boats (used for fishing or otherwise) that returned to a given ramp throughout the entire day, on all days of the year. The following analyses are based on comparisons of aerial counts and web camera counts (from both the primary and secondary ramps) on those days when both sources of data are available in each region (Table 1).

Table 1: Data available to assess the utility of secondary cameras in each region of FMA 1.

Region of FMA 1	Survey year	Scheduled days	Days flown [1]	Both cameras also working
East Northland	2004–05	48	42	40
	2011–12	45	34	24
Hauraki Gulf	2004–05	48	45	43
	2011–12	45	33	29
Bay of Plenty	2004–05	48	42	12[3]
	2011–12[2]	45	33	19

1 Aerial count data for some days are not available as flights were either cancelled or curtailed because of low cloud or heavy rain on some days.
2 Data from three days were dropped in this region because they occurred within six weeks of the grounding of the M.V. *Rena*, when a large area of water surrounding Motiti Island was temporarily closed to fishing.
3 The system at Whakatane was not operational until late April 2005.

2.3 Metrics used to evaluate the benefit of secondary cameras in each region

Three metrics are used to evaluate the utility of the primary and secondary cameras in each region.

Metric 1: Relative indices of effort over time

The first metric of utility that we considered was a simple comparison of regional indices of effort calculated for each ramp, and at both ramps combined, with that calculated from concurrent aerial survey data in each year. All three indices of average daily effort were normalised to an average of one, so that the trends in effort perceived from all four data sources could be compared.

Metric 2: Relationship between fishery effort and ramp traffic

The second metric of utility was an assessment of how well changing levels of traffic at each ramp reflect those of the wider regional fishery. Aerial counts of boats fishing through each region in 2004–05 and 2011–12 were regressed against web camera based counts of boats returning to both the primary and secondary ramps on the same days.

The level of traffic at some boat ramps can be constrained by the amount of parking available for boat trailers, and on busy days, some fishers may shift to other lesser ramps where more parking may be available. If this occurs at a ramp where a web camera is used to monitor trends in effort for the wider fishery, any resulting index of effort will be misleading. This bias would manifest itself as an asymptotic relationship between aerial counts and web camera based counts, as traffic at affected ramps can only reach a limited level on days when parking spaces for boat trailers become saturated.

Both linear and non-linear regressions were therefore performed on the data to determine whether saturation may have occurred on high effort days. Linear regressions were implemented using the *R* function *lm( )* and non-linear relationships were fitted using the function *nls( ),* as second order polynomials where

$$Ramp\ count = a\ (aerial\ count)^2 + b(aerial\ count)$$

Both the linear and non-linear regressions were forced through the origin. AIC statistics provided by the linear and non-linear regressions were compared to determine whether non-linear regression provided a better fit to the data for each combination of ramp and year, and the only best fitting model was ultimately selected. The difference between the linear and nonlinear AIC statistics must be at least 2.0 for a nonlinear model to provide a statistically improved fit to the data, as a degree of freedom is lost when an additional parameter is fitted in a nonlinear model.

Metric 3: Additional benefit of a second ramp in each region

For the third metric, Generalised Linear Modelling (GLM) was used to determine which ramp's counts best explained relative differences in daily levels of activity observed from the air, and the extent to which the addition of a second ramp's counts improved the fit to the model. All regressions were forced through the origin and each ramp's counts were offered to the model in a forward stepwise manner to the model.

1.4 Creel survey of fishers at each site

Many of the vessels observed on camera will have been used for purposes other than fishing, and in 2011–12 creel survey interviews were also conducted at ramps overlooked by web cameras to provide data on boat activity and catch rates of commonly caught species such as snapper.

Interviews followed a standardised format used in all previous boat ramp surveys conducted by MAF Fisheries and NIWA, ensuring that data were collected in a consistent and rigorously tested manner. Data were collected to determine whether or not a boat was used for fishing, 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. Usually the interviewer was able to measure the catch, 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).

The data collected during these surveys can therefore be used to estimate the proportion of the boats observed on camera that were used for fishing, and to estimate catch rates experienced by these boats. These data will ultimately be used to translate indices of fishing boat traffic into indices of catch, which are of more relevance to fisheries managers. These analyses will be undertaken as part of another Ministry for Primary Industries research project – MAF-2012/02: Web-camera monitoring of marine amateur fishing trailer boat effort.

The relative incidence of differing types of vessel activity and catch rates can vary considerably from day to day, and interviewers were therefore scheduled to work on the same days on which web camera imagery was interpreted. Interviewers were present at six of the boat ramps QMA 1 (see Figure 1), and at Shelly Beach and Raglan in QMA 9 and at New Plymouth in QMA 8. Interviewers were required to work a six hour afternoon shift on each day, during the afternoon and evening when most recreational boats return to shore.

3. RESULTS

3.1 Metrics used to evaluate the benefit of secondary cameras in each region

Relative indices of effort over time

The relative change in levels of effort observed at Waitangi between 2004–05 and 2011–12 was similar to that seen from concurrent aerial surveys of the East Northland fishery over the same period (Figure 2). This suggests that the web camera system at Waitangi provides a useful means of monitoring changing levels of recreational fishing effort in this region over the long term. Web camera based counts of boats returning to Parua Bay, however, suggest a far greater decline in effort than observed from the air, which suggests that the data provided by this camera may provide a misleading index of recreational effort.

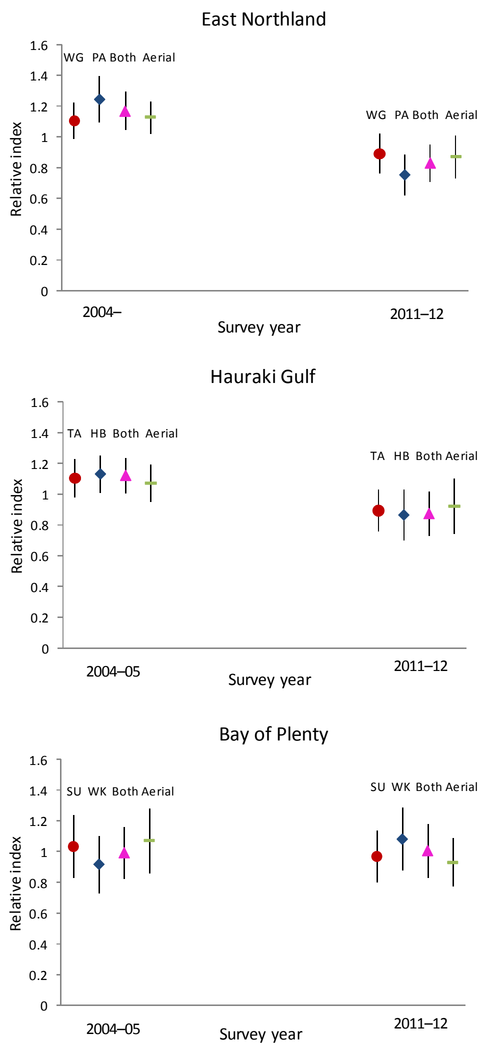

Figure 2: Comparison of relative indices of effort observed at each ramp, at both ramps combined and during aerial surveys during each survey year. Indices were calculated for the two East Northland ramps (WG – Waitangi and PA – Parua Bay) , two Hauraki Gulf ramps (TA – Takapuna and HB – Half Moon Bay) and two Bay of Plenty ramps (SU – Sulphur Point and WK – Whakatane).

In the Hauraki Gulf, trends in effort observed at both Takapuna and Half Moon Bay between 2004–05 and 2011–12 are very similar to those inferred from aerial survey data.

In the Bay of Plenty, both the aerial survey and Sulphur Point camera data suggest little difference in average levels of daily fishing effort between 2004–05 and 2011–12, but data from Whakatane suggests that fishing effort in 2011–12 was noticeably higher and this camera probably provides a misleading measure of changes in recreational fishing effort.

Relationship between fishery effort and ramp traffic

The relationship between aerial and camera based measures of daily fishing effort at the primary East Northland ramp, at Waitangi, is linear in 2004–05, but non-linear in 2011–12 (Figure 3). Levels of fishing effort in 2011–12 were no higher than in 2004–05, however, which suggests that the non-linearity in the second year may not be due to a saturation of the available parking spaces nearby. The slopes of the two relationships are broadly similar but the associated levels of correlation are relatively poor.

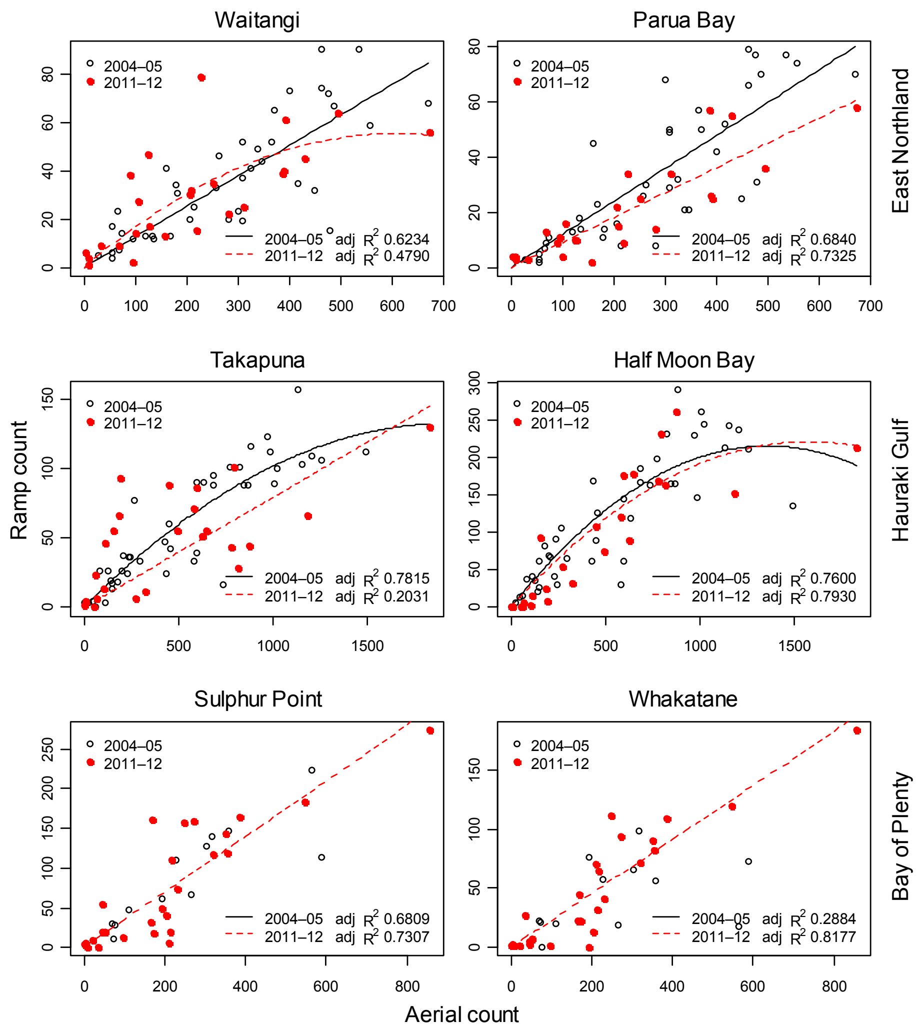

Figure 3: The relationships between: aerial counts and web camera counts at the primary ramp in each region (left panels); aerial counts and web camera counts at the secondary ramp in each region (right panels). Open black symbols and solid lines denote data collected in 2004-05 and solid red symbols and dashed lines denote data collected in 2011–12. Linear relationships were replaced with non-linear fits when the addition of an extra 2nd order polynomial parameter resulted in an AIC statistic significantly lower (<2.0) than that provided by the linear fit.

At the secondary East Northland ramp at Parua Bay there is no evidence of ramp saturation (nonlinearity) and there is a higher level of correlation between aerial and web camera counts in both years. The relativity between the aerial and web camera counts differs between years, however, which suggests that this ramp does not provide a consistent means of monitoring effort trends in the fishery over the long term.

In the Hauraki Gulf there is only limited evidence of effort saturation at the primary Takapuna ramp, but the degree of correlation between aerial and web camera based counts in 1011–12 was very poor (Figure 3). Levels of correlation were far higher in both years at Half Moon Bay but capacity at this ramp appears to be limited as to a maximum of about 200 to 250 boats per day.

There is a strong linear relationship between levels of fishing effort observed during aerial surveys and the number of boats returning to the ramp at Sulphur Point on the same surveyed day (Figure 3). This relationship appears to be consistent over time which suggests that this camera system provides a reliable means of monitoring levels of recreational fishing effort in the Bay of Plenty over the long term. Results for the secondary Bay of Plenty ramp at Whakatane are far less promising, as the relationships differ markedly between years, with clear evidence of nonlinearity in 2004–05. Fishers in the eastern Bay of Plenty sometimes have to launch their boats on the open coast when shifting sand bars at the entrance to the Whakatane harbour temporarily close this port.

Additional benefit of a second ramp in each region

A stepwise regression of data from East Northland suggested that counts from the current primary camera at Waitangi provided a good fit to the aerial counts with only a limited, although statistically significant, improvement in the model when counts provided by the secondary camera at Parua Bay were also considered (Table 2).

Table 2: Levels of deviance explained when daily counts provided by two web cameras in East Northland are offered to a stepwise regression of aerial survey count data.

	Deviance explained	R^2	P(>|Chi|)	
Waitangi	86.1%	0.693	< 2.2e-16	***
+ Parua Bay	4.4%	0.706	6.67e-08	***
Residual dev.	9.4%			

The GLM for the Hauraki Gulf selected data from the secondary ramp at Half Moon Bay first, before going on to select the data from the current primary ramp at Half Moon Bay (Table 3).

Table 3: Levels of deviance explained when daily counts provided by two web cameras in the Hauraki Gulf are offered to a stepwise regression of aerial survey count data.

	Deviance explained	R^2	P(>|Chi|)	
Half Moon Bay	88.0%	0.760	< 2.2e-16	***
+ Takapuna	2.7%	0.798	1.58e-05	***
Residual dev.	9.4%			

The existing web camera based indices of recreational effort for the Hauraki Gulf have been based on traffic counts provided by the primary Takapuna system, however, and not those provided by the secondary Half Moon Bay system selected initially by the GLM shown in Table 3. A second model was therefore used to evaluate the additional benefit gained from considering data provided from the secondary Half Moon Bay camera following the forced initial inclusion of data provided by the current primary ramp at Takapuna (Table 4). These results suggest that if the web camera at Takapuna remains in operation, then there may be some additional benefit in continuing to maintain the system at Half Moon Bay.

Table 4: Levels of deviance explained when daily counts provided by the camera at Takapuna are offered to a stepwise regression of aerial survey count data before counts provided by the system at Half Moon Bay.

	Deviance explained	R^2	P(>|Chi|)	
Takapuna	85.5%	0.72.9	< 2.2e-16	***
+ Half Moon Bay	5.1%	0.798	1.85e-09	***
Residual dev.	9.4%			

Web camera data from the Bay of Plenty were not assessed in this manner because the first two metrics clearly show that there is little merit in continuing to maintain the secondary camera at Whakatane, where harbour bar closures can lead to a closure of the ramp.

3.2 Companion creel survey

Interviewers were present at six boat ramps overlooked by web cameras in FMA 1, two in FMA 9 and one in FMA 8, on most of the 60 survey days preselected from the 2011–12 fishing year (Table 5). The shortfall at most ramps was due to a delayed start to field work. Substantial numbers of boats were approached by interviewers and these data should provide enough information to determine the proportion of vessels that were used for fishing purposes at each ramp and to describe the catch rates of commonly caught species. This is the first year in which interviewers have been scheduled to routinely work on web camera survey days, and no attempt will therefore be made to generate indices of fishing effort and catch until data are available from at least two consecutive years. A further creel survey is currently underway, which will provide interview data for the 2012–13 and 2013–14 fishing years, as part of Ministry for Primary Industries research project MAF-2012/02 Web-camera monitoring of marine amateur fishing trailer boat effort.

Table 5: Summary statistics for interview sessions conducted in QMAs 1, 8 and 9, as part of this programme.

Region	Ramp	Day type	Days worked	Hours worked	Fishing boats	Other activity	Not Interviewed	Refused	All boats
East Northland	Waitangi	Weekend	31	357	439	100	194	38	771
		Midweek	25	270	223	96	67	13	399
		Total	56	627	662	196	261	51	1 170
	Parua Bay	Weekend	31	361	326	47	62	3	438
		Midweek	25	263	166	36	19	2	223
		Total	56	623	492	83	81	5	661
Hauraki Gulf	Takapuna	Weekend	31	359	611	186	463	14	1 274
		Midweek	24	253	328	134	180	4	646
		Total	55	612	939	320	643	18	1 920
	Half Moon Bay	Weekend	31	668	1 497	390	957	51	2 895
		Midweek	25	471	561	198	231	15	1 005
		Total	56	1 138	2 058	588	1 188	66	3 900
Bay of Plenty	Sulphur Point	Weekend	30	626	1 282	335	300	7	1 924
		Midweek	24	391	514	126	191	10	841
		Total	54	1 017	1 796	461	491	17	2 765
	Whakatane	Weekend	31	352	615	69	417	42	1 143
		Midweek	25	247	241	34	178	6	459
		Total	56	599	856	103	595	48	1 602
QMA 9	Shelly Beach	Weekend	28	161	208	9	62	9	288
		Midweek	21	126	74	1	14	4	93
		Total	49	287	282	10	76	13	381
	Raglan	Weekend	22	132	285	32	135	14	466
		Midweek	18	107	57	12	10	2	81
		Total	40	240	342	44	145	16	547
QMA 8	New Plymouth	Weekend	25	142	476	112	493	11	1 092
		Midweek	22	128	183	68	221	16	488
		Total	47	270	659	180	714	27	1 580

2. DISCUSSION

The first objective of this study is to optimise the number of web cameras used to monitor trends in recreational fishing effort in FMA 1. Web camera systems have been installed overlooking two key boat ramps in each region of FMA 1 since 2005, but to date there has been no formal assessment of how many cameras are actually required to monitor trends in recreational effort each region. At least one boat ramp camera system should be maintained in each region, as regional trends in effort may diverge over time in response to differing levels of population growth and fish abundance. This study suggests that the number of camera systems required may differ between regions.

In East Northland the system overlooking the ramp at Waitangi appears to provide the best means of monitoring trends in effort in this region. The relationship between aerial and traffic counts at Waitangi in 2004–05 is broadly consistent with that seen in 2011–12 although some saturation of effort may have occurred at this ramp on busier days in 2011–12. At the alternative site at Parua Bay, however, aerial to ramp count relationships differ considerably between years, which suggests the web camera system at this ramp will not provide a reliable means of monitoring changes in levels of recreational fishing effort over the long term. Relative indices of effort based on combined daily counts from Waitangi and Parua Bay are no more similar to an index of aerial count data than that based on Waitangi count data alone. A stepwise GLM of camera data from the two East Northland ramps selected Waitangi first, and although the addition of count data from Parua Bay improved the model to a statistically significant degree, the level of improvement was only modest. These results suggest that there is little merit in continuing to maintain the secondary camera system at Parua Bay. Resources could be transferred from Parua Bay to provide a second independent web camera system at Waitangi, to ensure continuity of data should the existing primary system at this ramp fail.

In the Hauraki Gulf the results are more equivocal. The relationship between aerial and camera counts is more consistent at Half Moon Bay than at Takapuna, but Half Moon Bay appears to be more prone to saturation on busier days. Further parking spaces were established at Takapuna in late 2012, which should reduce the likelihood of saturation at this ramp in future years. There appears to be very little difference between indices of effort based on averaged daily traffic rates at Takapuna and at Half Moon Bay and those based on aerial flight data. All three data sources suggest a similar difference between levels of effort in 2004–05 and 2011–12. The similarity between the Half Moon Bay and Takapuna indices of effort means that a combined index would yield very similar results. Although a GLM selects Half Moon Bay first, a forced initial selection of data from Takapuna gives a similar degree of model fit to that if only one ramp is offered to the model, and little is gained from the fitting of data from a second Hauraki Gulf ramp to either model. Any assessment of the relative merits of these two camera systems is therefore uncertain, as each site has advantages over the other. There is probably merit in continuing to maintain both cameras over the long term, however, as the recreational fishery in the Hauraki is the largest in New Zealand, given its proximity to Auckland. The continued maintenance of both camera systems ensures continuity should either system fail.

In the Bay of Plenty, the web camera system at Sulphur Point provides a far better means of monitoring changes in recreational effort that that at Whakatane, regardless of the metric of utility considered. The ramp at Whakatane appears to be highly prone to saturation and the harbour entrance is often closed because the bar is impassable. The public boat ramp at Sulphur Point is perhaps the busiest access point in New Zealand and it accounts for a substantial proportion of the fishing effort in the Tauranga area. The relationship between aerial and ramp counts at this site was highly correlated, linear and consistent over time. A single system at Tauranga should therefore provide an adequate means of monitoring trends in recreational fishing effort in this region. This research establishes a strong evidential basis for a decision to disestablish the web camera system at Whakatane.

Although web cameras offer a means of monitoring trends in recreational boating effort, many of the vessels observed on camera will have been used for purposes other than fishing and further data are therefore required to translate indices of boating effort into indices of recreational catch, which are far more relevant to fisheries management. On ongoing creel survey was therefore initiated at the beginning of the 2011–12 fishing year, which will provide data on the proportion of vessels that are used for fishing purposes at each ramp and to describe the catch rates of commonly caught species. Ramp specific interview data on the relative daily proportion of boats used for fishing purposes will therefore be used to translate web camera based indices of boating effort into indices of fishing effort, which we will then combine with daily catch rate data to provide long term indices of harvest. Although creel survey data were collected for this purpose in 2011–12, the full analysis of these data and the derivation of fishing effort and harvest indices will not take place until data are available for a complete 24 month period. The ongoing maintenance of web camera systems and collection of concurrent creel survey data is currently being conducted as part of Ministry for Primary Industries research project MAF-2012/02 Web-camera monitoring of marine amateur fishing trailer boat effort. These creel survey data will be combined with web camera data as part of that programme, to provide regional indices of recreational harvest

4. ACKNOWLEDGMENTS

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