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Comparing 1994 Angler Catch and Harvest Rates from On-Site and Mail Surveys on Selected Maine Lakes

BRIAN ROACH*

Department of Resource Economics and Policy, University of Maine, Orono, Maine 04469, USA

JOAN TRIAL

Maine Department of Inland Fisheries and Wildlife, Bangor, Maine 04401, USA

KEVIN BOYLE

Department of Resource Economics and Policy, University of Maine, Orono, Maine 04469, USA

Abstract.—Fishery managers use data on catch and harvest rates collected with both on-site and off-site angler surveys. Many researchers have hypothesized that catch rates from these surveys will differ systematically due to various biases. However, few direct comparisons have been made between the two survey methods using the same waters and seasons. We compared catch and harvest rates for three coldwater species, individually and combined, from concurrent mail and on-site surveys on five Maine lakes during the 1994 ice fishing season. Comparisons were also made for two Maine lakes during the 1994 open-water season. Estimates of catch and harvest from the mail survey exceeded the rates from on-site surveys in 28 of 38 comparisons for individual species. The average on-site to mail survey ratio was 0.40 for catch rates and 0.66 for harvest rates but varied significantly by lake, season, and species. The results suggest that mail surveys do not produce accurate estimate of catch and harvest rates. In situations where only mail survey data are available, fisheries managers should recognize that mail survey catch and harvest rates are likely to be overestimates compared with on-site data.

Fisheries managers can obtain angler catch and harvest rates using either on-site or off-site (mail or telephone) surveys. The methods are used in different situations to capitalize on the advantages and disadvantages of each (Essig and Holliday 1991). On-site surveys are conducted on individual waters with fish retained by anglers counted and measured by a clerk. Because fish harvest is observed by a clerk, on-site surveys result in accurate estimates of fish harvest (Newman et al. 1997). Clerks may also inquire about the species and number of fish released. Off-site mail or telephone surveys have been used extensively, and usually include many waters within a large geographic area, such as a state or province, because a random sample of anglers is obtained from all fishing license records. Off-site surveys are generally less expensive to administer than on-site surveys. Problems associated with off-site surveys include low response rates and longer recall periods. In addition, there is no way to assess if respondents are accurately reporting catch, harvest, and number of trips.

Despite the prevalence of both survey formats, only a few direct comparisons between the two formats have been made, and these have produced conflicting results. Angler reported catch and harvest of Atlantic salmon *Salmo salar* on Nova Scotia rivers were higher than those from on-site law enforcement surveys and from statistically designed surveys of a single pool (Claytor and O'Neil 1991). Angler reported estimates of harvest from the mail surveys were 28–134% higher than on-site values, and estimates of fish released were 169–356% higher in the mail surveys. Thus, the number of fish harvested were reported more accurately by anglers than numbers caught and released. In comparing telephone and on-site surveys at five Missouri reservoirs, Weithman and Haverland (1991) found that estimates of catch and harvest rates were about 20% higher from the on-site surveys for all species combined. With five reservoirs, each with several species in their fisheries, there were 40 possible species–reservoir combinations. Estimated rates from on-site surveys were significantly higher than estimates based on the mail survey in about 45% of the species–reservoir pairs and lower for only 12 of the species–reservoir pairs. However, the two surveys were not directly comparable. The on-site surveys

* Corresponding author: broach@maine.maine.edu

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covered about 14% of the reservoir area and were conducted during daylight hours for 9 months; the telephone survey encompassed the entire reservoir area, included the entire year, and covered both day and night angling.

More states are conducting off-site surveys to gather information on a larger number of lakes than could possibly be surveyed on-site in a single year. Thus, managers may find that the only angler survey data available on a lake are from an off-site survey. For fisheries biologists to be comfortable using these data in management decisions, they need to understand how catch and harvest rates from the two surveys are related. We compared on-site and mail survey catch and harvest rates of legal-sized fish on five selected Maine lakes during the 1994 ice fishing season and two lakes during the 1994 open-water season, testing the hypothesis that self-reported rates were higher than those collected on-site.

Methods

Data for this paper were obtained from two sources. On-site creel surveys were conducted in 1994 at more than 30 lakes selected by Maine Department of Inland Fisheries and Wildlife (MDIFW) personnel. These surveys collected information by species on the number and size of fish harvested and released by an angling party. The number of anglers in the party, time fished, and whether the party had completed fishing were also recorded. Multiple partial-day trips by a party on a lake were recorded as a single days' fishing with the sum of hours for the partial trips being the time spent fishing. Most of the on-site surveys took place during the entire season, with survey days randomly selected from weekday and weekend strata. With the exception of northern Maine lakes, where anglers were also asked to report fish catch data for trips during the previous week, only day-of-trip data were collected by roving clerks or with access site interviews.

The off-site surveys were conducted by the University of Maine and sponsored by MDIFW. The ice fishing mail survey, conducted in the spring of 1994, gathered data from a random sample of 5,000 anglers from license records (MacDonald et al. 1995). The survey asked anglers to list all sites they ice fished during the 1993–1994 season, along with information about the number of days fished and the number of legal-sized fish, by species, caught (released plus harvested) and harvested. A second survey, conducted in the fall of 1994, gathered data for open-water, or summer, fishing from a different random sample of 5,000 anglers (MacDonald et al. 1996).

We compared the number of legal fish caught (harvested plus released) and harvested per fishing day by anglers interviewed in the on-site and mail surveys. Legal catch and harvest rates per day were compared because hourly rates could not be obtained from the mail surveys. In the mail survey, the number of fish caught and harvested was divided by the number of days an angler reported fishing a water. Although on-site surveys included both completed and incomplete trips, we only used the data from completed trips. Our primary concern was that low daily bag limits would affect harvest rates on incomplete trips (Pollock et al. 1997). Daily party catch and harvest were divided by the number of anglers. Thus, the rates calculated for both surveys were fish per angler-day.

The choice of lakes for comparisons started with the lists of waters covered by both surveys in 1994. On-site survey data were available for five waters during the open-water season and 31 waters during the winter season. However, many of these lakes could not be included in the analysis due to insufficient concurrent data from the mail surveys. Although the mail survey resulted in catch and harvest data for hundreds of waters, many sites were visited by only a few anglers. Jones et al. (1995) suggested that catch rates could be estimated with about 90% confidence when 30 anglers are interviewed. Catch rates based on data from 100 anglers increase the confidence level to 95%. Using the 100 angler criterion, our analysis would have been restricted to only Moosehead and Sebago lakes. Both surveys were slight exceptions to the usual on-site design. On Moosehead Lake, in both winter and summer, angling rates were obtained for all fishing days in the past week in addition to the day of the interview. The open-water survey on Sebago Lake did not include the first and last months of the season, which may bias catch and harvest rates. To include lakes in our analyses with Maine's standard on-site survey design, we chose to conduct comparisons for lakes with at least 40 observations from each survey. This resulted in five lakes being included in the analysis for the ice fishing season: Moosehead, Sebago, Schoodic, and Square lakes and Cold Stream Pond; the first two were also used for comparisons during the open-water season. A minimum sample size of 40 assures at least 90% confidence that the catch and harvest rates are representative. Also, it exceeds the requirement of 25

TABLE 1.—Species daily limit (number) and length regulations (in) on selected Maine lakes for the 1993–1994 ice fishing and 1994–1995 open-water seasons.

Water body and season	Brook trout		Lake trout		Atlantic salmon		
	Number	Length (in)	Number	Length (in)	Number	Length (in)	Salmonid daily limit[a]
Moosehead Lake[b]							
Open	1	12	1	18	2	14	2
			1	14–18			
Ice	1	12	1	18	1	18	2
			1	14–18			
Sebago Lake[c]							
Open	2	8	3	18	1	16	6
Ice	0	na[d]	3	18	0	na[d]	3
Cold Stream Pond[b,c]							
Ice	3	6	1	18	1	14	3
			1	14–18			
Square Lake							
Ice	2	12	2	18	1	14	3
Schoodic Lake							
Ice	2	6	3	14	1	14	5

[a] Aggregate of brook trout, lake trout, and Atlantic salmon. Note that the total salmonid catch limit is not necessarily the sum of the individual species limits.
[b] Daily harvest limit on lake trout is two fish; one must be between 14 and 18 in and one must be greater than 18 in.
[c] Number of lines limited to two in winter.
[d] Not applicable since no harvest permitted.

observations for the statistical test we used to make the comparisons (Mendenhall et al. 1990).

Although both the on-site and mail surveys gathered data on legal catch and harvest for a variety of species, only landlocked Atlantic salmon, brook trout *Salvelinus fontinalis*, and lake trout *S. namaycush* were included in the analysis as they were the most frequently targeted cold-water species. Because daily harvest limits were low for individual species (Table 1), we also compared total salmonid catch and harvest for the two surveys. However, total salmonid harvest was constrained on all but Sebago Lake by aggregate daily limits (Table 1).

Catch and harvest rates commonly display a Poisson distribution (Hoenig et al. 1997), thus parametric tests are inappropriate. We used the nonparametric Wilcoxon rank-sum test for independent samples using the NPAR1WAY procedure in SAS (SAS Institute 1994). Our hypothesis was that catch and harvest rates were higher from the mail surveys than the on-site surveys. The means of the ratios for interviewed parties or anglers were obtained from both surveys (Hoenig et al. 1997; Lockwood 1997). The relationships between the rates were assessed using the ratio of on-site to mail survey means. A Wilcoxon paired rank-sum test was used to test the hypothesis that mail survey harvest rates were reported more accurately than catch rates. We set an a priori significance level of $\alpha = 0.10$ for all tests.

Results and Discussion

The response rate of the winter mail survey was 71%, and the open-water survey had a response rate of 62%. Although these response rates are comparable with or better than those normally obtained in mail surveys, the possibility of nonresponse bias remains. Among the lakes used for comparison, sample sizes in the mail survey ranged from 44 to 403 responses; the lowest number of interviews in an on-site survey was 134 (Tables 2, 3).

On each lake, on-site and off-site catch and harvest rates were highest for either landlocked Atlantic salmon or lake trout, never for brook trout (Tables 2, 3). On-site survey catch rates for brook trout were all less than 0.050 fish/d; lake trout and landlocked Atlantic salmon catch rates ranged from 0.007 to 1.133 fish/d (Table 3). In general, catch rates were higher in winter than during the open-water season. Of the 14 comparisons made for the open-water season, the mail survey rate was significantly higher ($P < 0.1$) in 11 instances. For the ice fishing season, the mail survey rate was significantly higher in 26 of 38 comparisons.

Considering all comparisons, the rates from the mail survey were significantly higher in 37 of 52

TABLE 2.—Legal catch and harvest rates (ratio of means estimator) from mail and on-site angler surveys during the 1994 Maine open-water season. Daily rates between surveys were compared within each lake by species (*P*-values for Wilcoxon rank-sum test).

Species	Catch per day			Harvest per day		
	On-site	Mail	*P*	On-site	Mail	*P*
Moosehead Lake (*N* = 656, on-site; 180, mail)						
Lake trout	0.155	0.582	0.0001	0.047	0.120	0.0001
Brook trout	0.045	0.159	0.0001	0.027	0.051	0.0001
Atlantic salmon	0.175	0.591	0.0001	0.065	0.122	0.0001
All salmonids	0.375	1.332	0.0001	0.139	0.293	0.0001
Sebago Lake (*N* = 168, on-site; 212, mail)						
Lake trout	0.164	0.271	0.0020	0.109	0.120	0.1050
Brook trout[a]						
Atlantic salmon	0.262	0.504	0.0027	0.139	0.113	0.7138
All salmonids	0.426	0.805	0.0035	0.249	0.241	0.6236

[a] Harvest rate in on-site = 0, off-site survey < 0.008.

cases (71%). Catch and harvest rates from the mail survey exceeded rates from on-site surveys in 28 of 38 individual species comparisons (Tables 2, 3). This self-reporting bias did not seem to be related to bag or length regulations (Table 1) or on-site catch rate for any of the species. Mail survey respondents reported catching and harvesting lake trout on Square Lake and brook trout on Cold Stream Pond, while none of these species were seen during the on-site surveys (Table 3). Harvest of landlocked Atlantic salmon and brook trout were reported in the mail survey for Sebago Lake in winter (Table 3), even though it was illegal to harvest the two species (Table 1). These findings

TABLE 3.—Legal catch and harvest rates (ratio of means estimator) from mail and on-site angler surveys during the 1994 Maine winter ice fishing season. Daily rates between surveys were compared within each lake by species (*P*-values for Wilcoxon signed rank test).

Species	Catch per day			Harvest per day		
	On-site	Mail	*P*	On-site	Mail	*P*
Cold Stream Pond (*N* = 184, on-site; 47, mail)						
Lake trout	0.124	0.082	0.5705	0.088	0.051	0.5414
Brook trout	0.005	0.104	0.0001	0.000	0.082	0.0001
Atlantic salmon	0.095	0.393	0.0001	0.083	0.237	0.0007
All salmonids	0.224	0.578	0.0003	0.172	0.370	0.0044
Moosehead Lake (*N* = 566, on-site; 403, mail)						
Lake trout	0.464	1.476	0.0001	0.252	0.323	0.0001
Brook trout	0.049	0.204	0.0001	0.037	0.093	0.0001
Atlantic salmon	0.012	0.778	0.0369	0.012	0.068	0.0001
All salmonids	0.525	2.461	0.0001	0.300	0.482	0.0001
Schoodic Lake (*N* = 134, on-site; 56, mail)						
Lake trout	0.266	0.439	0.1032	0.217	0.170	0.6884
Brook trout	0.014	0.124	0.0001	0.010	0.080	0.0002
Atlantic salmon	0.007	0.110	0.0001	0.007	0.066	0.0020
All salmonids	0.287	0.674	0.0016	0.234	0.317	0.1015
Sebago Lake (*N* = 137, on-site; 181, mail)						
Lake trout	0.623	0.383	0.9197	0.547	0.252	0.9992
Brook trout[a]						
Atlantic salmon	0.014	0.107	0.0001	0.000	0.028	0.0102
All salmonids	0.638	0.493	0.7294	0.547	0.282	0.9960
Square Lake (*N* = 178, on-site; 44, mail)						
Lake trout	0.000	0.069	0.0001	0.000	0.060	0.0001
Brook trout	0.305	0.722	0.0143	0.140	0.291	0.0871
Atlantic salmon	1.133	1.643	0.3422	0.676	0.487	0.9990
All salmonids	1.438	2.463	0.0201	0.962	0.842	0.8524

[a] Harvest rate in on-site = 0, off-site survey < 0.002.

may signify recall bias, illegal behavior, or a failure to properly identify species.

Of the ten individual species comparisons in which mail survey rates did not exceed on-site rates, three were for Atlantic salmon and seven were for lake trout. Combined species catch and harvest rates differed on a lake only if mail survey rates exceeded on-site rates for the species with the highest rates (Tables 2, 3). For brook trout, mail survey catch and harvest rates exceeded rates from the on-site survey in every comparison (Tables 2, 3). It seems that anglers reported lake trout catches more accurately than brook trout or Atlantic salmon catches. All lakes used for the comparisons were large (between 3,400 and 77,000 acres); as a result, brook trout were probably not targeted, and catches were low in both seasons. Atlantic salmon, when targeted, can be caught at a relatively high rate, which may be easily exaggerated. Lake trout were often the largest species in the catch, in part as a result of greater length limits (Table 1), and their catch could be more memorable. On Moosehead Lake, where rates for the two surveys differed for lake trout in both seasons, high numbers of sublegal lake trout were reported released during the on-site survey. Thus, fish size was small, and lake trout catch might have been less memorable. On Sebago Lake, lake trout were the only species that could be legally harvested in winter, thus probably the only species targeted in the fishery.

The ratios of on-site catch rates to mail catch rates (on-site survey rate divided by mail survey rate) were significantly lower than those for harvest rates (Table 4). The average ratio for catch rates was 0.40 and the average ratio for harvest rates was 0.66. Thus, like Claytor and O'Neil (1991) we found that anglers self-reported harvest more accurately than numbers of legal fish caught (harvested and released). Anglers may be less likely to inflate harvest numbers because harvesting a fish tends to be memorable and is constrained by daily bag limits.

Managers have always suspected that catch and harvest data based on mail surveys were overestimates, due in part to recall bias and nonresponse bias. Our study confirms this suspicion. We found that self-reported catch and harvest rates from mail surveys tend to be higher than rates from concurrent on-site surveys. The difference between the two surveys was greater for catch rates than for harvest rates. However, the relationships between the two surveys were not consistent for the three species examined. The ratio of on-site to mail surveys varied by lake, season, and species (Table 4), averaging 0.40 for catch and 0.66 for harvest. Managers should not use mail surveys data if on-site surveys are available. However, mail survey data are better than no data. As long as managers recognize that mail survey catch and harvest rates are likely to be overestimates compared with the on-site data, mail surveys can still provide valuable data in individual lake management. The data can be used to select lakes for on-site surveys; develop trends in use and catch, harvest, or release rates; and even make management decisions in conjunction with biological sampling.

TABLE 4.—Comparison of the ratios of on-site survey catch and harvest rates to mail survey rates on selected Maine lakes for the 1993–1994 ice fishing and 1994–1995 open-water seasons; overall means were significantly different (Wilcoxon paired signed rank test, $P = 0.0001$).

Lake and species	Catch rate ratio (on-site/mail)	Harvest rate ratio (on-site/mail)
Open-water season		
Moosehead		
Lake trout	0.25	0.36
Brook trout	0.23	0.47
Atlantic salmon	0.31	0.52
All salmonids	0.27	0.45
Segabo		
Lake trout	0.48	0.62
Atlantic salmon	0.52	1.42
All salmonids	0.49	0.90
Ice fishing season		
Cold Stream Pond		
Lake trout	1.10	0.98
Brook trout	0.11	0.00
Atlantic salmon	0.22	0.27
All salmonids	0.38	0.40
Moosehead		
Lake trout	0.31	0.73
Brook trout	0.25	0.43
Atlantic salmon	0.01	0.17
All salmonids	0.20	0.60
Schoodic		
Lake trout	0.45	1.26
Brook trout	0.14	0.14
Atlantic salmon	0.10	0.16
All salmonids	0.37	0.81
Sebago		
Lake trout	1.21	1.60
Atlantic salmon	0.14	0.00
All salmonids	1.03	1.55
Square		
Lake trout	0.00	0.00
Brook trout	0.46	0.53
Atlantic salmon	0.76	1.49
All salmonids	0.66	1.30
Overall mean	0.40	0.66

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