SEDAR 17-RD22

North American Journal of Fisheries Management 23:573–580, 2003

Exaggeration of Walleye Catches by Alberta Anglers

MICHAEL G. SULLIVAN*

Alberta Fish and Wildlife Service,
7th Floor, O. S. Longman Building,
6909 116th Street, Edmonton, Alberta T6H 2P4, Canada

Abstract.—I studied anglers' exaggeration of catches of walleyes *Stizostedion vitreum* at Alberta sport fisheries to determine whether trends in reported catches were indicative of actual trends. To quantify anglers' exaggeration, I compared the ratios of protected-length to legal-length walleyes as reported by anglers with similar ratios confirmed from test angling at 22 walleye sport fisheries from 1991 to 2000. Overall, anglers reported catching 2.2 times more protected-length walleyes per legal-length walleyes than were caught in the test-angling fisheries. Exaggeration in catches was not constant but increased exponentially with decreasing catch rate. On-site exaggeration, in combination with further exaggeration in mail surveys, results in the reported catch rate declining at a lower rate than the actual catch rate, thereby causing a perception of hyperstability in the fishery. Hyperstability has profound implications for biologists who manage fisheries based on reported data because reported catch rates may provide little warning of a fisheries collapse.

Many sport fisheries are managed using catch-and-release or length-limit regulations, so fisheries managers must increasingly rely on anglers' reports of fish catches as a monitoring tool rather than observation and counting of the harvest. Managers must also depend on reported catches whenever catches are not directly observed, such as through mail and telephone surveys. Errors in reporting the actual catch using off-site techniques have both been assumed (Essig and Holliday 1991; Pollock et al. 1994) and demonstrated (Claytor and O'Neil 1991; Roach et al. 1999). Generally, off-site survey techniques should not be used for estimating catch (Jacobson et al. 1983). The low cost of these techniques, however, provides a strong motivation for using indirect methods as fisheries monitoring tools (Smith 1983; Weithman and Haverland 1991).

On-site creel surveys are generally preferred to off-site techniques and are assumed to yield accurate harvest data because creel clerks can directly observe and tally anglers' catch (Newman et al. 1997). Huntsman et al. (1978), however, noted that on-site surveys do not allow for calculation of the true numbers of released fish because anglers may exaggerate their catches when reporting to creel clerks.

Fisheries managers often assume that exaggeration by anglers is constant and that trends in reported catches are indicative of stock status (MacDonald and Dillman 1968; Huntsman et al. 1978; Jacobson et al. 1983). By accepting this assumption, managers can use the reported catch as an index of harvest or abundance and supposedly illustrate trends in the actual catch or catch rate. In contrast (and prior) to these authors, Jenson (1964) described how fisheries managers in California stopped using mail surveys as indices for fisheries for Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss* because known harvest trends were not shown.

In Alberta, anglers' catch reports have become increasingly important as a monitoring tool. The sport fishery for walleyes in Alberta exerts heavy fishing pressure on boreal systems with low productivity. Harvest rates for walleyes *Stizostedion vitreum* at accessible fisheries were typically below 0.1 fish per angler-hour, and more than 90% of anglers were unsuccessful in harvesting a walleye during a fishing trip (Berry 1995). In 1996, restrictive angling regulations were imposed on all walleye fisheries in Alberta. Many fisheries became catch and release only, with most of the remainder being managed using large (43 or 50 cm total length [TL]) minimum length limits. Anglers must now typically release more than 85% of their walleye catch.

The main technique for monitoring walleye sport fisheries in Alberta involves access-point creel surveys at individual lakes. Creel surveys are necessary to determine angler effort as well as harvests of walleyes and other fish species (mainly northern pike *Esox lucius* and yellow perch *Perca flavescens*). Assessment of the status of walleye fisheries depends on biological data collected from anglers' harvests and on catch data derived from

* Corresponding author: michael.g.sullivan@gov.ab.ca

Received June 12, 2001; accepted July 1, 2002

interviews with anglers. With the increase in catch-and-release regulations, monitoring became more dependent on reported trends.

My objectives were to test the assumption that anglers exaggerate their catch, and, if true, to determine whether exaggeration is constant with respect to the actual catch. To meet these objectives, I developed a technique for comparing the length ratios of walleyes caught in test-angling fisheries to the length ratios reported and observed in the creel surveys. I used this technique in studies from 1991 to 2000 at 22 walleye sport fisheries in Alberta. I also analyzed data from the published literature to quantify the additional exaggeration that occurs between the time of on-site creel surveys and mail surveys.

Methods

I conducted my research at a series of easily accessible and popular sport fishing lakes in northern Alberta (north of 54° latitude; Table 1) and have treated each year of study at each lake as a separate fishery. Most anglers fished exclusively for walleyes, although some also reported catching northern pike and yellow perch. Much of this work was part of a study of angler compliance, and the study sites, methods, and a discussion of the assumptions are given in greater detail in Sullivan (2002).

In brief, anglers reported catching and releasing a number of protected-length walleyes, but I doubted the accuracy of their reports. To estimate the actual number of protected-length walleyes that were caught, I used the following method. Creel clerks tallied anglers' catch of legal-length walleyes and anglers' reported catch of protected-length walleyes. Test angling was used to estimate the ratio of protected-length walleyes to legal-length walleyes caught in the sport fishery. I then extrapolated this test fishery ratio to the sport fishery using anglers' catch of legal-length walleyes as the denominator. The resulting numerator is my estimate of the number of protected-length walleyes caught in the sport fishery. Bailey's modification of a Lincoln–Petersen index (Ricker 1958) was used in this extrapolation. Confidence intervals for the estimate of numbers of protected-length walleyes caught in the sport fishery were calculated using the exact method for binomial proportions (Zar 1999). Exaggeration was calculated as the number of protected-length walleyes that anglers reported catching compared with the estimated number of protected-length walleyes that were caught.

I also analyzed data from Roach et al. (1999) to quantify anglers' exaggeration in mail surveys (using their Tables 2 and 3 [catch per day] to derive exaggeration) and could thereby combine the two levels of angler exaggeration.

Angler catch and harvest data were collected from access-point, completed-trip creel surveys of sport fisheries during the summer angling season. Creel clerks interviewed all anglers returning to the survey access-point during each survey day. Surveys involved two levels of sampling intensity: anglers were interviewed on either 70% or 35% of all days from mid-May to mid-August. At the study lakes, virtually all anglers fished from boats and were interviewed upon returning to shore from their fishing trips. Creel clerks asked anglers the number of hours that they had spent fishing and the number of protected-length walleyes that they had released. All harvested walleyes were tallied and a random subset was sampled for biological information. Creel clerks were not in uniform, had no enforcement authority, and were instructed to be as casual and nonofficial as possible.

To derive the ratio of protected-length to legal-length walleyes caught in the sport fishery, fisheries staff and local volunteers test-angled for walleyes at the study lakes. To avoid possible seasonal size selectivity, a variety of dates were chosen for fishing throughout the angling season (mean = 15.6 different test fishing dates at each lake; range = 5–32; Table 1). On each test fishery day, at least 2 anglers, and as many as 60, would participate. Test anglers were instructed to catch walleyes using whatever lures or techniques they would normally use when angling at these lakes. All walleyes caught in test fisheries were measured to the nearest millimeter of fork length (FL) and then released.

Catch rates were calculated as total ratio estimators (Malvestuto 1983). Catch refers to the number of fish caught, which includes both harvested and released fish unless otherwise stated. Reported catch rate and on-site catch rate (used by Roach et al. 1999) are the same and are calculated from the catch and number of angler-hours reported by anglers to the creel clerks at each lake. Mail catch rate refers to the value calculated from the catch and number of angler-hours reported by anglers in mail surveys. I use angler exaggeration as a synonym for self-reporting bias (Roach et al. 1999). Angler exaggeration would encompass prestige bias and social desirability bias (MacDonald and Dillman 1968; Pollock et al. 1994). Exaggeration factor refers to the ratio of reported

TABLE 1.—Lake area, walleye length limit, and parameters used to calculate exaggeration at 22 Alberta sport walleye fisheries, 1991–2000. Abbreviations are as follows: PL = number of protected-length walleyes; LL = number of legal-length walleyes; CI = confidence interval. The exaggeration factor is defined as the ratio of reported PL to estimated PL caught.

			Creel survey (tallies from interviews)				Test fishery			Estimates	
Lake and year	Walleye length limit[a]	Area (ha)	Anglers	Hours	PL reported	LL kept[b]	Days of test fishing[c]	PL	LL	PL caught (95% CI)	Exaggeration factor
Seibert 1992	42–53 slot	3,790	2,104	6,955.0	1,272	41	7	79	9	356 (198–898)	3.6
Seibert 1993	42–53 slot	3,790	2,030	6,366.0	1,544	32	32	136	6	684 (357–2,207)	2.3
Seibert 1994	42–53 slot	3,790	1,036	3,310.5	515	27	4	104	15	193 (119–381)	2.7
Touchwood 1991	42–53 slot	2,900	2,512	6,640.0	286	95	14	59	50	121 (83–183)	2.4
Touchwood 1992	42–53 slot	2,900	3,785	10,348.0	399	85	18	91	45	185 (131–277)	2.2
Touchwood 1994	42–53 slot	2,900	3,477	9,547.0	841	147	16	92	40	363 (254–553)	2.3
Touchwood 1997	42–53 slot	2,900	2,947	8,444.5	2,128	313	19	109	41	894 (634–1,345)	2.4
Pinehurst 1993	38 min.	4,070	8,845	28,541.0	16,946	3,229	7	49	34	4,973 (3,238–8,178)	3.4
Pinehurst 1994	38 min.	4,070	5,181	16,756.5	8,230	2,120	13	191	135	3,275 (2,633–4,144)	2.5
Pinehurst 1997	43 min.	4,070	3,414	12,217.5	7,881	1,039	9	595	118	5,715 (4,721–7,085)	1.4
Smoke 1998	43 min.	959	958	2,844.0	3,704	124	6	202	8	3,061 (1,714–8,080)	1.2
Iosegun 1998	43 min.	1,340	907	2,815.5	3,172	271	8	395	33	3,463 (2,498–5,253)	0.9
Shiningbank 1998	43 min.	463	1,178	2,538.0	60	13	30	5	6	10 (3–47)	5.9
Baptiste 1997	50 min.	981	825	2,888.5	1,690	78	16	255	17	1,216 (788–2,246)	1.4
Baptiste 1999	50 min.	981	643	2,338.5	1,786	27	26	255	4	1,515 (730–7,042)	1.2
Elinor 1996	50 min.	933	938	2,665.0	566	17	5	133	6	355 (185–1,150)	1.6
Hilda 1997	50 min.	337	290	717.0	231	11	11	54	3	163 (71–1,088)	1.4
May 1996	50 min.	301	72	253.0	13	2	13	92	31	6 (4–10)	2.1
Rock Island 1996	50 min.	2,078	501	1,619.5	341	61	14	24	14	107 (57–241)	3.2
Pinehurst 2000	50 min.	4,070	1,572	6,330.0	4,870	435	18	282	63	2,108 (1,625–2,861)	2.3
Beaver 1998	50 min.	3,310	2,037	6,427.0	4,526	74	29	522	4	8,498 (4,114–38,681)	0.5
Beaver 2000	50 min.	3,310	1,278	4,005.0	3,120	42	20	264	8	1,355 (760–3,563)	2.3
Totals (or means)			46,530	144,567	64,121	8,283	15.6	3,988	690	38,611	2.2

[a] Slot limits (ranges) and minimum (min.) length limits (single numbers), both in cm total length.
[b] In estimating PL caught, LL kept was increased by 10% to account for released legal-length walleyes.
[c] Number of dates that test fisheries were held during the angling season; not a measure of fishing effort.

catch to estimated catch. Factors of 1, therefore, indicate no observed difference between reported catch and estimated catch. Exaggeration factors less than 1 mean that reporting bias is negative (i.e., anglers reported catching fewer fish than were estimated caught).

Results

From 1991 to 2000, 22 walleye fisheries were studied to estimate exaggeration factor (Table 1). The average exaggeration factor for the catch of protected-length walleyes was 2.2 (Table 1). Only 2 of 22 fisheries (Iosegun 1998 and Beaver 1998)

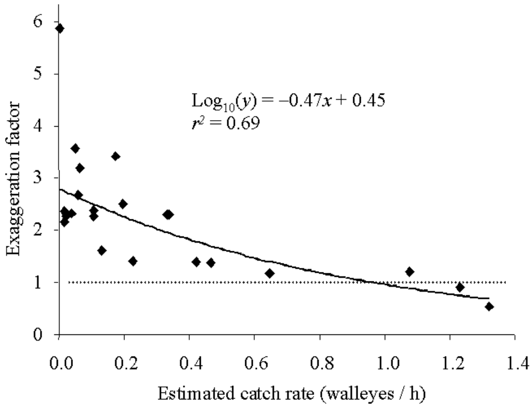

FIGURE 1.—Exaggeration factor as a function of estimated catch rate for protected-length walleyes in 22 Alberta angler surveys in 1991–2000. The dashed line indicates an exaggeration factor of 1 (i.e., the estimated catch rate equals the reported catch rate). Score test for nonconstant variance of residuals: F = 0.36; df = 1, 20; P = 0.55 (Weisberg 1985).

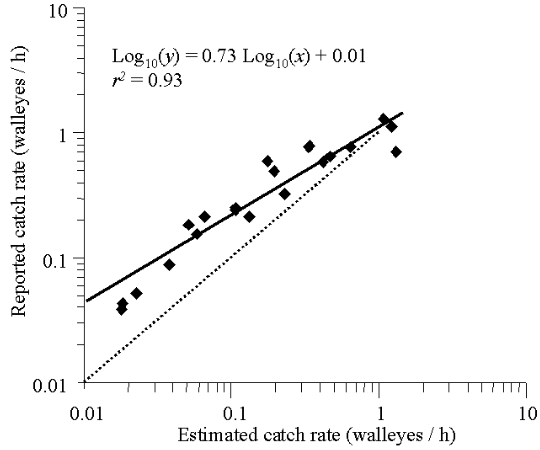

FIGURE 2.—Reported catch rate as a function of estimated catch rate for protected-length walleyes in 22 Alberta angler surveys in 1991–2000. The dashed line indicates that the estimated catch rate equals the reported catch rate. Score test for nonconstant variance of residuals: F = 0.35; df = 1, 20; P = 0.56 (Weisberg 1985).

showed exaggeration factors of less than 1 (although their confidence intervals included 1), meaning that anglers may not have exaggerated at these two fisheries but rather underestimated their catch of walleyes. Both of these fisheries had high catch rates for protected-length walleyes (>1.0 fish per angler-hour).

The exaggeration factor was negatively correlated with the catch rate for protected-length walleyes (r^2 = 0.69, df = 21, P < 0.001; Figure 1). The reported catch rate was significantly correlated with the estimated catch rate in a logarithmic relationship but declined more slowly than the estimated catch rate (r^2 = 0.93, df = 21, P < 0.001; Figure 2), showing that the bias in the reported catch rate was not constant with respect to catch rate.

This exaggeration in catch rates from on-site surveys is additive to the exaggeration from mail surveys. Roach et al. (1999) compared catch rates from a mail survey with catch rates recorded at the same lakes during on-site creel surveys. My analysis of their published data shows a good relationship (r^2 = 0.68, df = 17, P < 0.001) between exaggeration factor and on-site catch rate (Figure 3). Integration of these two levels of exaggeration (from estimated catch to on-site and from on-site to mail survey) resulted in a pattern of perceived hyperstability in catch rates, with a sudden drop in the reported catch rate at very low estimated catch rates (Figure 4).

Discussion

A major assumption of my technique for estimating anglers' exaggeration is that the length distribution of walleyes caught by test anglers is the same as the length distribution of walleyes caught by sport anglers. Test anglers may be more skilled and so may catch larger walleyes than sport anglers, thereby creating a bias that would cause an

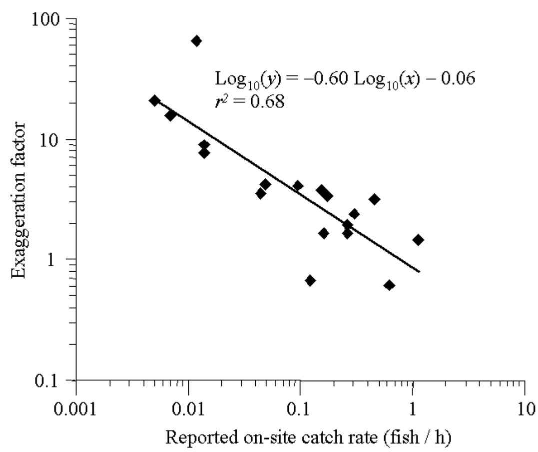

FIGURE 3.—Exaggeration factor in mail surveys (i.e., the ratio of mail survey catch rate to on-site catch rate) relative to the catch rate reported by anglers during onsite surveys for salmonid fisheries in Maine. Data are from Roach et al. (1999). Score test for nonconstant variance of residuals: F = 0.11; df = 1, 16; P = 0.74 (Weisberg 1985).

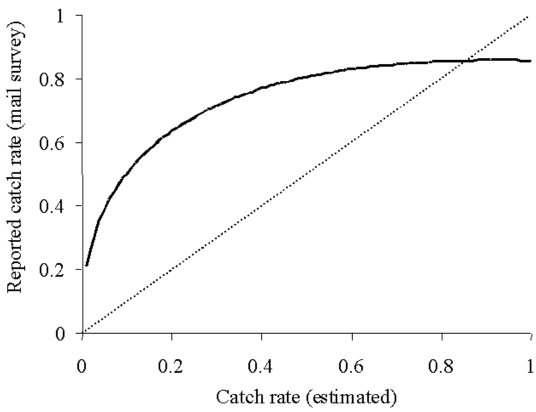

FIGURE 4.—Estimated catch rate as exaggerated in on-site surveys (from this study) and on-site catch rate as exaggerated in mail surveys (derived from data from Roach et al. 1999) showing perceived hyperstability in the reported catch rate. The solid line is the integrated relationship of estimated catch rate as exaggerated in mail surveys, and the dashed line indicates that the estimated catch rate equals the mail survey catch rate.

overestimate of the exaggeration factor. To avoid this bias, test-angling techniques closely simulated those in the sport fishery (i.e., test anglers had varying skill levels, used a variety of gears, and angled throughout the fishing season). Catch rates for the two fisheries do not need to be comparable as they are not used in this analysis; only the ratios of protected-length to legal-length fish were analyzed. To avoid biases caused by seasonal changes in the length frequency distribution of walleyes, test fisheries were held on numerous dates throughout the summer. The length frequency distribution of walleyes caught in the test fisheries, however, did not change over the angling season.

Confidence intervals around the estimates of the catch of protected-length walleyes were large, primarily because of the small sample sizes of legal-length walleyes in the test fisheries. Although these confidence intervals often encompassed the reported catch, the best estimate of anglers' catch is the central estimate. Increasing exaggeration with declining catch rate is, therefore, the best estimate of the actual relationship. Reducing these confidence intervals was usually impractical. Many of the walleye sport fisheries were severely depressed or collapsed and had correspondingly low catch rates. It was, therefore, logistically impractical to test-angle large numbers of big walleyes and thereby reduce the range of the confidence intervals. When planning test-angling fisheries in Alberta, biologists now use the number of legal-length walleyes to determine the sampling effort necessary to achieve the desired level of precision of catch estimate.

Because of the short time between actual catches and on-site interviews, recall bias was probably not a major factor in the exaggeration measured in my studies. Recall bias was important in the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (Fisher et al. 1991), where reported lengths and numbers of angling trips increased with time away from the activity. Cannel et al. (1977) found that in most social surveys, as recall time increases, the reporting of an event was also likely to be distorted in a socially desirable direction. Recall bias would probably cause an increase in reported catches of fish and could be the major factor in differences between this information from on-site surveys and from mail surveys.

In this study, anglers exaggerated more as fishing success declined. People may respond to questionnaires according to their beliefs in the purpose and outcomes of testing (Page 1999). Similarly, ''role faking,'' in which a respondent to psychological testing answers questions in a manner that he or she perceives to be consistent with an idealized social role and not one's true identity, is believed to be a general human strategy (Kroger and Turnbull 1975). These two related psychological biases comprise prestige bias (Jacobson et al. 1983) and could be responsible for anglers exaggerating their catches of fish, especially at those lakes with very low catch rates where anglers may be embarrassed to admit that they failed to catch any fish. Prestige bias was implicated by MacDonald and Dillman (1968) in hunter surveys, where, in contrast to the male-to-female ratio of deer *Odocoileus* spp. brought in by hunters to check stations, deer hunters surveyed by mail reported shooting more bucks than does. Jacobson et al. (1983) provided a good review of the psychological biases associated with delayed data collection systems as related to fisheries studies.

My data show that exaggeration occurs between the time of catching (or not catching) a fish and landing one's boat on shore. In salmonid fisheries in Maine, a similar pattern of exaggeration was shown by Roach et al. (1999), with anglers interviewed at the lake and later by mail. Further analysis of their data, as well as mine, shows that exaggeration was related to catch rate. Because exaggeration measured in mail surveys occurs after anglers have already been interviewed on shore (thereby including on-site exaggeration in their response), these two levels of exaggeration (i.e., catch exaggerated in on-site surveys and further exaggerated in mail surveys) are additive. The outcome of repeated exaggeration is probably most severe when using angler surveys (such as telephone surveys, mail surveys, internet surveys, and licence-return surveys) that are distant in time or space from the actual fishing event. The validity of using off-site surveys for monitoring fish catches should be seriously questioned where catch rates are low or declining. Acknowledging the exaggeration inherent in mail surveys, Roach et al. (1999) stated that mail survey data are better than no data at all. If the levels and trends in exaggeration seen in my study (and their study) are a general phenomenon, then such survey data would actually present a false picture by masking declines in fisheries. Unless the bias is quantified during data collection, I would refute Roach et al.'s statement and counter with the adage ''No data are better than false data.'' Mail surveys are useful for gathering many types of data, but catch and harvest data (and any resulting trends) should be considered suspect, especially if recall periods are long or catch rates may be declining.

In my study, which compared estimated to on-site catches, exaggeration occurred only at low catch rates. My review of published studies comparing on-site to mail surveys also showed this pattern to be common. Calhoun (1950) and Baxter and Young (1953) found no exaggeration but used annual records involving large catches of fish (California freshwater and marine angling data). Murphy (1954) compared catch data from angler interviews and mail surveys from the Little Salmon River, Idaho, and found no consistent bias in this high catch rate fishery (>1.0 fish per angler-hour). Weithman and Haverland (1991) found that catch rates were generally underestimated in telephone surveys compared with on-site roving creel surveys at a variety of Missouri reservoirs with catch rates of more than 0.18 fish per angler-hour. Their harvested fish data, however, showed exaggeration at catch rates less than 0.1. Exaggeration at low catch rates was shown in the following studies: Jenson (1964) for California salmon *Oncorhynchus* spp. fisheries; Bjornn (1965) for salmon and steelhead fisheries in Idaho; MacDonald and Dillman (1968) for surveys of deer hunters; Carline (1972) for brook trout *Salvelinus fontinalis* fisheries; Claytor and O'Neil (1991) for Atlantic salmon *Salmo salar* fisheries in Nova Scotia; and Roach et al. (1999) for salmonid fisheries in Maine. Although some of this exaggeration is probably a function of nonresponse bias (Carline 1972; Connelly and Brown 1992), there also appears to be a general pattern of exaggeration at low catch rates.

Management Implications

Additive levels of exaggeration and the fact that the rate of exaggeration increases at low catch rates (<0.1 fish per angler-hour) result in reported catch rates failing to be an index of declining catch rates. Hilborn and Walters (1992) show that hyperstability in catch rates masks the actual decline in certain fish populations. The exaggeration that I calculated from anglers' reported catches would further inflate the perception of stable fish populations. This perceived hyperstability has considerable importance to managers. As fisheries decline, anglers will increase their rates of exaggeration, and any real decline in catches is thereby masked if mail or phone survey data are used. This trend continues until actual catch rates are so low that even high levels of exaggeration result in reports of very low catch rates (i.e., at an actual catch rate of 0.005, exaggerating by a factor of 10 results in a reported catch rate of 0.05; both are still very low). In a declining fishery, initial reports result in the perception of hyperstability, followed by the perception of hyperdepletion at very low catch rates (Hilborn and Walters 1992). Fisheries managers relying on this type of data for monitoring a declining fishery may assume that the fishery is stable until confronted with a sudden and catastrophic collapse. This misperception and depensatory effect is further intensified if the actual catch rate is related to the fish population density, following a pattern of hyperstability such as that proposed by Korver et al. (1996).

The biases reported here will result in a depensatory response by anglers to declining fisheries. As fisheries decline, anglers will increase their exaggeration. Managers relying primarily on angler reports to manage a fishery will fail to detect the actual decline until the fishery collapses. Ludwig et al. (1993) stated several principles of effective resource management, of which the first two were (1) include human motivation and responses and (2) act before scientific consensus is achieved. The results of this study reinforce the importance of these principles.

Acknowledgments

I am grateful to the members of the Alberta Fisheries Workshop (Mike Bryski, Craig Johnson, Dave Park, Bill Patterson, Dee Ryerson, Stephen Spencer, George Sterling, and Jordan Walker) for their assistance. Funding for the creel surveys was provided by the Fisheries Management Enhancement Program and the Alberta Conservation Association. I thank Hugh Norris and Lincoln Chew for extensive assistance. John Post provided much thoughtful discussion and coined the term ‘‘perceived hyperstability.’’ Dominic Baccante, Lee Foote, Naomi Krogman, and Heidi Zwickel provided valuable reviews and editing of this manuscript.

References

Baxter, J. L., and P. H. Young. 1953. An evaluation of the marine sportfishing record system in California. California Fish and Game 39:343–353.

Berry, D. K. 1995. Alberta's walleye management and recovery plan. Alberta Environmental Protection, Natural Resources Service, Publication T/310, Edmonton.

Bjornn, T. C. 1965. Methods used to estimate salmon and steelhead harvests in Idaho (June 1965). Idaho Department of Fish and Game 1993:89 (Article 12).

Calhoun, A. J. 1950. California angling catch records from postal card surveys: 1936–1948, with an evaluation of postal card nonresponse. California Fish and Game 36:177–234.

Cannel, C. F., L. O. Oksenberg, and J. M. Converse. C 1977. Striving for response accuracy: experiments in new interviewing techniques. Journal of Marketing Research 14:306–315.

Carline, R. F. 1972. Biased harvest estimates from a postal survey of a sport fishery. Transactions of the American Fisheries Society 101:262–266.

Claytor, R. R., and S. F. O'Neil. 1991. Using small creel Tsurveys and mark–recapture experiments to interpret angling statistics. Pages 195–205 *in* D. Guthrie, J. M. Hoenig, M. Holliday, C. M. Jones, M. J. Mills, S. A. Moberly, K. H. Pollock, and D. R. Talhelm, editors. Creel and angler surveys in fisheries management. American Fisheries Society, Symposium 12, Bethesda, Maryland.

Connelly, N. A., and T. L. Brown. 1992. Item response bias in angler expenditures. Journal of Leisure Research 24:288–294.

Essig, R. J., and M. C. Holliday. 1991. Development of Ia recreational fishing survey: the marine recreational fishery statistics survey case study. Pages 245–254 *in* D. Guthrie, J. M. Hoenig, M. Holliday, C. M. Jones, M. J. Mills, S. A. Moberly, K. H. Pollock, and D. R. Talhelm, editors. Creel and angler surveys in fisheries management.. American Fisheries Society, Symposium 12, Bethesda, Maryland.

Fisher, W. L., A. E. Grambsch, D. L. Eisenhower, and RED. R. Morganstein. 1991. Length of recall period and accuracy of estimates from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Pages 367–374 *in* D. Guthrie, J. M. Hoenig, M. Holliday, C. M. Jones, M. J. Mills, S. A. Moberly, K. H. Pollock, and D. R. Talhelm, editors. Creel and angler surveys in fisheries management. American Fisheries Society, Symposium 12, Bethesda, Maryland.

Hilborn, R., and C. Walters. 1992. Quantitative fisheries Istock assessment: choice, dynamics, and uncertainty. Chapman and Hall, New York, New York.

Huntsman, G. R., D. R. Colby, and R. L. Dixon. 1978. Measuring catches in the Carolina headboat fishery. Transactions of the American Fisheries Society 107: 241–245.

Jacobson, J. O., R. D. Cook, and R. Sopuck. 1983. An Tevaluation of alternative methods of collecting sportfishing statistics for the Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 1180.

Jenson, P. T. 1964. Landing estimates of California's Imarine recreational salmon fishery. California Fish and Game 50:48–52.

Korver, R. M., N. P. Lester, B. J. Shuter, and M. L. Jones. L 1996. Density-dependent catchability in angling fisheries, or do you suffer from q-suction? Paper presented at the 126th American Fisheries Society annual meeting, Dearborn, Michigan, August 25–29, 1996.

Kroger, R. O., and W. Turnbull. 1975. Invalidity of validity scales: the case of the MMPI. Journal of Consulting and Clinical Psychology 43:48–55.

Ludwig, D., R. Hilborn, and C. Walters. 1993. UncerAtainty, resource exploitation, and conservation: lessons from history. Science 260:17, 36.

MacDonald, D., and E. G. Dillman. 1968. Techniques Afor estimating non-statistical bias in big-game harvest surveys. Journal of Wildlife Management 32: 119–129.

Malvestuto, S. P. 1983. Sampling the recreational fishery. Pages 397–419 *in* L. A. Neilsen and D. L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Murphy, L. W. 1954. Two-year creel census of the Little Salmon River, Idaho. Transactions of the American Fisheries Society 84:200–206.

Newman, S. P., P. W. Rasmussen, and L. M. Andrews. 1997. Comparison of a stratified, instantaneous count creel survey with a complete mandatory creel census on Escanaba Lake, Wisconsin. North American Journal of Fisheries Management 17:321–330.

Page, S. 1999. Two studies of gender reporting differences with the Beck Depression Inventory. Current Research in Social Psychology 4:146–159.

Pollock, K. H., C. M. Jones, and T. L. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society, Special Publication 25, Bethesda, Maryland.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 119.

Roach, B., J. Trial, and K. Boyle. 1999. Comparing 1994 angler catch and harvest rates from on-site and mail surveys on selected Maine lakes. North American Journal of Fisheries Management 19:203–208.

Smith, C. L. 1983. Evaluating human factors. Pages 431–445 *in* L. A. Neilsen and D. L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Sullivan, M. G. 2002. Illegal angling harvest of walleyes protected by length limits in Alberta. North American Journal of Fisheries Management 22:1053–1063.

Weithman, A. S., and P. Haverland. 1991. Comparability of data collected by telephone and roving creel surveys. Pages 67–73 *in* D. Guthrie, J. M. Hoenig, M. Holliday, C. M. Jones, M. J. Mills, S. A. Moberly, K. H. Pollock, and D. R. Talhelm, editors. Creel and angler surveys in fisheries management. American Fisheries Society, Symposium 12, Bethesda, Maryland.

Weisberg, S. 1985. Applied linear regression. Wiley, New York.

Zar, J. H. 1999. Biostatistical analysis, 4th edition. Prentice-Hall, Englewood Cliffs, New Jersey.