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ARTICLE

A Reward-Recovery Study to Estimate Tagged-Fish Reporting Rates by Idaho Anglers

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Abstract
From 2006 to 2009, we tagged and released 22,202 fish with T-bar anchor tags valued at US$0 to $200 if returned. Our intent was to assess angler tag reporting rates in Idaho and to determine whether reporting rates declined over time or differed between species. A total of 4,643 tags were reported by anglers. Assuming a reporting rate of 100% for $200 tags, weighted mean reporting rates were 54.2% for $0 tags, 69.7% for $10 tags, 91.7% for $50 tags, and 98.9% for $100 tags. By combining $100 and $200 as high-reward tags to increase sample size, nonreward tag-reporting rate was 54.5%. Tag reporting rates varied between groups of species, being highest for harvest-oriented species, both coolwater and warmwater, such as walleye *Sander vitreus* ($0 = 68.3%), yellow perch *Perca flavescens* (58.5%), and crappie *Pomoxis* spp. (59.7%), and lowest for largemouth bass *Micropterus salmoides* (39.2%). There was little variation in tag-reporting rates over time, weighted means being 53, 56, 50, and 56% from 2006 to 2009, but reporting rate did appear to decline for some species (most notably crappies). There was some evidence of a slight violation of the assumption of independence in tag-reporting, indicated by nonreward tag-reporting rates being marginally higher for anglers reporting both nonreward and reward tags than for those reporting only one or the other (signifying possible batch-reporting of tags). No batch-reporting was evident from differences in reporting rates for households reporting multiple tags compared with those reporting only one tag. Our results suggest that anglers in Idaho reported over half the nonreward tags they encountered, but rates appeared to vary among species, and this knowledge is being used to estimate angler exploitation across Idaho.

Angler exploitation can have an important influence on the structure of sport fish communities via effects on recruitment, mortality, and growth. Even when it is negligible, knowing the exploitation rate of a fishery is often useful for fishery managers to address public concerns and to track changes in exploitation over time. However, estimating exploitation can be extremely difficult and labor-intensive (Miranda et al. 2002), and techniques to estimate exploitation include numerous assumptions that, when violated, may introduce a great deal of uncertainty to estimates.

One of the most common techniques for estimating exploitation consists of releasing a known number of marked fish with tags and relying on angler tag returns to estimate the proportion harvested (reviewed in Pollock et al. 2001; Miranda et al. 2002; Pine et al. 2003). This method requires that the actual tag reporting rate be estimated, which can be problematic because the number of tags encountered by anglers and not reported is typically unknown. The willingness of an angler to report a tag from a harvested fish is therefore a critical facet of an exploitation study that uses voluntary tag returns, although it is generally the variable with the highest uncertainty. There are several methods used to estimate tag-reporting rates, but arguably the most accurate and convenient method is the high-reward tag method, where both nonreward and high-reward tags are released, and the nonreward tag reporting rate is estimated as the relative recovery rate of nonreward tags to that of high-reward tags (Nichols et al. 1991; Pollock et al. 2001).

The primary assumption of the high-reward method is that the high reward is sufficient incentive for anglers to report 100% of the high-reward tags they encounter. Numerous investigations,

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conducted over a broad spectrum of species, systems, and geographic areas, have estimated the reward amount needed to elicit a 100% response rate (e.g., Conroy and Blandin 1984; Weaver and England 1986; Eder 1990; Haas 1990; Murphy and Taylor 1991; Nichols et al. 1991; Jenkins et al. 2000; Schultz and Robinson 2002). Many such studies have had important limitations, including small sample sizes and assumptions with little to no supporting data that the high-reward tags achieved a 100% reporting rate. Other studies have used combinations of either nonmonetary rewards (e.g., hats, shirts, patches, beer) or lottery-type programs, which probably increases tag reporting rates but usually to an unknown degree (reviewed in Pollock et al. 2001). Another factor that could influence tag-reporting rate includes the independence of tag reporting, which could be affected by whether an angler is turning in only one tag or multiple tags, or whether having a reward tag to report affects the rate of nonreward tag reporting. An angler's general awareness of the tagging program may also affect an angler's likelihood of reporting tags, as may their opinion of the agency conducting the program, the ease of reporting tags, the size and species of the fish, and whether the fishery is harvest-based or catch-and-release-oriented.

Tag-reporting rates reported within the fisheries literature are quite variable, ranging from 15% to 92% for a variety of fish species in various lotic and lentic environments across the USA (e.g., Rawstron 1971; Moring 1980; Green et al. 1983; Colvin 1991; Larson et al. 1991; Maceina et al. 1998; Miranda et al. 2002; Schultz and Robinson 2002). Because of the variability in the literature, and the limitations frequently noted in many previous studies, the Idaho Department of Fish and Game (IDFG) has often relied on the results of the seminal study by Nichols et al. (1991), in which variable reward-response curves were developed for reporting of bands on mallards *Anas platyrhynchus*. This study reported a 32% reporting rate for nonreward bands and determined that the reward amount needed to generate a 100% reporting rate was approximately US$100. However, there is considerable uncertainty in applying tag reporting rates derived from duck hunters to angler tag reporting rates in Idaho. Consequently, the objectives of this study were to (1) determine if tag reporting rates for Idaho anglers differed in relation to reward level, target species, time, and whether or not anglers (or households) had reported more than one tag, and (2) determine the level of reward required to elicit a 100% tag-reporting rate.

METHODS

From 2006 to 2009, we tagged 22,202 fish distributed across 25 waters statewide with Floy FD-68BC T-bar anchor tags (Table 1). Tags were fluorescent orange, 70 mm in length (51 mm of tubing), and were treated with algaecide. Tags were labeled on two sides, with one side stating the agency and phone number and the other side listing a tag number and reward amount if applicable. A toll-free automated telephone number and website were established through which anglers could report tags, although some tags were mailed in or dropped off at IDFG offices. Anglers were required to turn in reward tags for payment. Tags were returned to anglers after they were processed, along with a letter that provided all the known information for the tagged fish.

Informational posters and stickers were distributed to IDFG license vendors, regional offices, and sporting goods stores to publicize the tagging efforts, explain how the information was being used, and provide tag reporting instructions. No other information was provided to anglers, and informational signs were not posted at individual bodies of water in order to examine the efficacy of future site-specific exploitation estimates not dependent on labor-intensive sign maintenance activity at each site that tagged fish are released.

The primary species tagged were white crappie *Pomoxis annularis*, black crappie *P. nigromaculatus*, largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, and hatchery and wild rainbow trout *Oncorhynchus mykiss* (Table 1). White crappie and black crappie often occur in sympatry in Idaho waters, and anglers generally do not distinguish between the species, so they were combined during analyses. Other species tagged in the study were yellow perch *Perca flavescens*, walleye *Sander vitreus*, brook trout *Salvelinus fontinalis*, cutthroat trout *O. clarkii*, and rainbow trout × cutthroat trout hybrids.

Wild fish were typically collected using a boat-mounted electrofisher (DC settings of 300–600 V, about 60 Hz, and a 4–8-ms pulse width for about a 40% duty cycle and an average output of 1–5 A). During electrofishing, fish were captured and placed in a live well in small quantities until they were tagged and released near where the fish were captured to ensure good distribution of tags. Wild trout were also captured at weirs. Hatchery trout that were used in this study were netted out of the raceway, anesthetized, tagged, and held in a pen within the raceway until stocking. All species were tagged below the dorsal fin following the recommendations of Guy et al. (1996). To reduce the rate of tagging mortality, individual fish were judged up to the point of release as to whether they were unfit for our study due to visible signs of stress from the capture and handling procedures (Ryan 1990; Vreeland 1990; Nielsen 1992). Tagged fish were always of harvestable size based on angling regulations and angler desirability.

Tags consisted of five reward levels: \$0 (also referred to as nonreward), \$10, \$50, \$100, and \$200, which were generally applied at rates of 76%, 8%, 8%, 4%, and 4%, respectively (Table 2). The high-reward values were based on the finding by Nichols et al. (1991) that approximately US\$100 was needed to generate a 100% reporting rate that in 2006 dollars translated to \$163, which we bounded by using \$100 and \$200.

Angler nonreward tag reporting rate (λ) was estimated using the relative reporting rate of nonreward tags (R) to that of high-reward (N) tags (Pollock et al. 2001):

$$\lambda = \frac{R_r/R_t}{N_r/N_t},$$

TABLE 1. Summary of site-specific tagging results for various species of wild and hatchery fish (crappie includes both white and black crappies). The table includes only those tagging events with estimates based on at least five high-reward ($100 and $200) tag returns. Reporting rate estimates are 95% confidence intervals about the mean.

				Number of tags released by reward value					Number of tags returned by reward value					
Year	Water body	Species	Origin	$0	$10	$50	$100	$200	$0	$10	$50	$100	$200	Reporting rate estimate[a]
2006	Brownlee Reservoir	Crappie	Wild	449	34	40	19	22	111	12	15	9	5	72.4 ± 40.2
2007	Brownlee Reservoir	Crappie	Wild	399	42	42	21	21	108	10	21	10	10	56.8 ± 27.1
2008	Brownlee Reservoir	Crappie	Wild	379	40	40	20	20	73	9	12	10	9	40.5 ± 20.5
2009	Brownlee Reservoir	Crappie	Wild	398	42	42	21	21	85	9	15	9	7	56.1 ± 29.9
2006	CJ Strike Reservoir	Crappie	Wild	210	22	16	9	9	54	9	6	2	4	77.1 ± 65.1
2008	CJ Strike Reservoir	Crappie	Wild	382	40	40	20	20	110	16	21	10	8	64.0 ± 31.9
2009	CJ Strike Reservoir	Crappie	Wild	380	40	40	19	19	112	17	20	10	16	43.1 ± 18.4
2006	Mann Lake	Crappie	Wild	252	24	24	12	13	111	15	16	5	13	61.2 ± 30.5
2006	Ben Ross Reservoir	Largemouth bass	Wild	108	12	7	7	9	13	2	2	2	3	38.5 ± 39.7
2007	Ben Ross Reservoir	Largemouth bass	Wild	227	23	25	12	12	47	9	12	7	6	38.2 ± 23.5
2006	Pend Oreille River	Largemouth bass	Wild	332	36	37	17	16	94	18	24	13	12	37.4 ± 16.5
2006	Brownlee Reservoir	Smallmouth bass	Wild	392	33	45	19	19	92	15	17	11	11	40.5 ± 18.9
2007	Brownlee Reservoir	Smallmouth bass	Wild	399	42	42	21	21	80	7	10	5	10	56.1 ± 31.0
2008	Brownlee Reservoir	Smallmouth bass	Wild	382	40	40	20	20	109	18	27	8	10	63.4 ± 31.6
2009	Brownlee Reservoir	Smallmouth bass	Wild	342	36	36	18	18	51	8	9	7	7	38.3 ± 22.7
2006	CJ Strike Reservoir	Smallmouth bass	Wild	292	31	30	15	14	90	10	16	8	6	63.8 ± 36.0
2007	CJ Strike Reservoir	Smallmouth bass	Wild	379	40	40	20	20	144	17	22	11	8	80.0 ± 38.3
2008	CJ Strike Reservoir	Smallmouth bass	Wild	381	40	39	20	20	92	10	15	9	10	50.8 ± 25.1
2009	CJ Strike Reservoir	Smallmouth bass	Wild	381	40	40	21	21	104	19	17	13	9	52.1 ± 24.0
2007	Dworshak Reservoir	Smallmouth bass	Wild	383	40	40	20	20	96	18	22	12	10	45.6 ± 21.1
2006	Milner Reservoir	Smallmouth bass	Wild	401	40	40	20	20	134	18	18	12	10	60.8 ± 27.4
2009	Oakley Reservoir	Walleye	Wild	224	24	24	12	12	39	2	9	5	1	69.6 ± 59.9
2007	Salmon Falls Ck. Reservoir	Walleye	Wild	559	42	42	21	21	123	7	12	7	7	66.0 ± 36.5
2009	Cascade Reservoir	Yellow perch	Wild	379	40	40	20	20	61	7	11	3	8	58.5 ± 37.6
2007	SF Snake River	Rainbow trout and hybrids	Wild	521	48	48	24	24	72	10	13	6	6	55.3 ± 33.8
2006	Williams Lake	Rainbow trout	Wild	226	26	25	12	12	40	6	5	6	5	38.6 ± 25.8
2007	Williams Lake	Rainbow trout	Wild	228	24	24	12	19	20	3	4	2	4	45.3 ± 41.3
2008	Anderson Ranch Reservoir	Rainbow trout	Hatchery	606	60	65	31	32	26	2	8	3	3	45.0 ± 40.0
2007	Boise River	Rainbow trout	Hatchery	380	40	40	20	19	89	12	18	11	7	50.7 ± 25.7
2006	Chesterfield Reservoir	Rainbow trout	Hatchery	378	36	37	20	20	38	2	6	3	9	33.5 ± 21.7
2007	Glendale Reservoir	Rainbow × cutthroat hybrid	Hatchery	379	39	40	20	19	87	14	17	12	10	40.7 ± 19.0
2006	Lake Walcott	Rainbow trout	Hatchery	698	98	100	47	48	86	19	19	8	14	53.2 ± 24.9
2007	Mann Creek Reservoir	Rainbow trout	Hatchery	380	40	41	20	20	76	10	18	4	11	53.3 ± 29.5
2006	Mann Lake	Rainbow trout	Hatchery	343	40	40	20	20	58	5	7	5	4	75.2 ± 52.8
2007	NF Payette River	Rainbow trout	Hatchery	670	72	67	36	36	53	9	6	8	6	40.7 ± 24.0
2008	Ririe Reservoir	Cutthroat trout	Hatchery	380	40	41	20	20	29	5	9	5	3	38.2 ± 29.9

[a]Based on using $100 and $200 tags as high rewards.

where R_t and R_r are the numbers of nonreward tags released and reported, respectively, and N_t and N_r are the numbers of high-reward tags released and reported. Reporting rates were similarly estimated for tags with other dollar values. Variance was calculated according to Henny and Burnham (1976), from which 95% confidence intervals (CIs) were calculated.

Tag-reporting rates were estimated by species and year, and site-specific reporting rates were made for tagging events with at least five high-reward tags returned; we deemed estimates based on fewer than five high-reward tag returns to be suspect. In one instance (crappies tagged in CJ Strike Reservoir in 2007), estimated nonreward reporting rate was over 100%, which is theoretically illogical; consequently, we did not attempt to estimate a site-specific reporting rate for that instance.

We evaluated whether our study design violated the assumption of independence of tag returns. This problem occurs when anglers return batches of tags (Pollock et al. 2001). The most likely way this could happen is if anglers held onto one or more nonreward tags without reporting them, but if they later caught a reward tag, they might then report the nonreward tags with the reward tag. Another example is cumulative tag returns, where anglers might become more likely to report several nonreward tags in their household (saving postage, or time spent on the phone or computer) than they would be for only

TABLE 2. Yearly pooling of the total number of fish initially tagged (N_{tag}) and number reported (N_{rep}) and tag reporting percentage ($R_{\%}$) for various dollar amounts (assuming that $200 elicited a 100% reporting rate). Reporting rates are 95% confidence intervals about the mean.

	$0			$10			$50			$100			$200			Reporting rates				
Year	N_{tag}	N_{rep}	$R_{\%}$	N_{tag}	N_{rep}	$R_{\%}$	N_{tag}	N_{rep}	$R_{\%}$	N_{tag}	N_{rep}	$R_{\%}$	N_{tag}	N_{rep}	$R_{\%}$	$0[a]	$0[b]	$10[a]	$50[a]	$100[a]
Crappie (black and white crappies combined)																				
2006	911	276	30.3	80	36	45.0	80	37	46.3	40	16	40.0	44	22	50.0	60.6 ± 7.2	67.0 ± 7.9	90.0 ± 12.9	92.5 ± 30.1	80.0 ± 39.6
2007	765	221	28.9	80	24	30.0	80	33	41.3	41	15	36.6	41	17	41.5	69.7 ± 9.3	74.0 ± 9.8	72.4 ± 11.0	99.5 ± 34.4	88.2 ± 45.1
2008	761	183	24.0	80	25	31.3	80	33	41.3	40	20	50.0	40	17	42.5	56.6 ± 8.3	52.0 ± 7.6	73.5 ± 13.6	97.1 ± 33.5	117.6 ± 52.3
2009	778	197	25.3	82	26	31.7	82	35	42.7	40	19	47.5	40	23	57.5	44.0 ± 6.2	48.2 ± 6.8	55.1 ± 8.9	74.2 ± 24.8	82.6 ± 37.5
Total	3,215	877	27.3	322	111	34.5	322	138	42.9	161	70	43.5	165	79	47.9	57.0 ± 3.8	59.7 ± 4.0	72.0 ± 5.2	89.5 ± 15.0	90.8 ± 21.3
Smallmouth bass																				
2006	1,191	328	27.5	106	43	40.6	117	52	44.4	55	32	58.2	54	27	50.0	55.1 ± 6.0	50.9 ± 5.5	81.1 ± 10.8	88.9 ± 24.4	116.4 ± 40.8
2007	1,161	320	27.6	122	42	34.4	122	54	44.3	61	28	45.9	61	28	45.9	60.0 ± 6.6	60.0 ± 6.6	75.0 ± 9.6	96.4 ± 25.9	100.0 ± 37.3
2008	763	201	26.3	80	28	35.0	79	42	53.2	40	17	42.5	40	20	50.0	52.7 ± 7.3	57.0 ± 7.9	70.0 ± 11.7	106.3 ± 32.6	85.0 ± 40.8
2009	723	155	21.4	76	27	35.5	76	26	34.2	39	20	51.3	39	16	41.0	52.3 ± 8.3	46.4 ± 7.3	86.6 ± 20.2	83.4 ± 32.4	125.0 ± 55.7
Total	3,838	1,004	26.2	384	140	36.5	394	174	44.2	195	97	49.7	194	91	46.9	55.8 ± 3.5	54.1 ± 3.4	77.7 ± 5.4	94.1 ± 14.0	106.0 ± 21.2
Largemouth bass																				
2006	440	107	24.3	48	20	41.7	44	26	59.1	24	15	62.5	25	15	60.0	40.5 ± 7.7	39.7 ± 7.6	69.4 ± 18.4	98.5 ± 38.6	104.2 ± 53.8
2007	227	47	20.7	23	9	39.1	25	12	48.0	12	7	58.3	12	6	50.0	41.4 ± 12.0	38.2 ± 11.0	78.3 ± 40.2	96.0 ± 56.4	116.7 ± 90.5
Total	667	154	23.1	71	29	40.8	69	38	55.1	36	22	61.1	37	21	56.8	40.7 ± 6.5	39.2 ± 6.2	72.0 ± 15.7	97.0 ± 31.3	107.7 ± 45.6
Hatchery trout																				
2006	2,554	251	9.8	293	30	10.2	295	46	15.6	147	23	15.6	148	28	18.9	51.9 ± 6.4	56.8 ± 7.0	54.1 ± 8.6	82.4 ± 23.9	82.7 ± 33.9
2007	2,187	311	14.2	230	46	20.0	228	61	26.8	116	36	31.0	114	36	31.6	45.0 ± 5.0	45.4 ± 5.1	63.3 ± 9.2	84.7 ± 21.3	98.3 ± 32.2
2008	986	55	5.6	100	7	7.0	106	17	16.0	51	8	15.7	52	6	11.5	48.3 ± 12.8	41.0 ± 10.9	60.7 ± 36.8	139.0 ± 67.0	135.9 ± 95.4
Total	5,727	617	10.8	623	83	13.3	629	124	19.7	314	67	21.3	314	70	22.3	48.3 ± 3.8	49.4 ± 3.9	59.8 ± 5.8	88.4 ± 15.6	95.7 ± 23.0
Wild trout																				
2006	921	115	12.5	86	17	19.8	87	14	16.1	46	12	26.1	42	10	23.8	52.4 ± 9.6	49.9 ± 9.2	83.0 ± 26.4	67.6 ± 35.7	109.6 ± 62.8
2007	1,418	110	7.8	146	13	8.9	145	22	15.2	73	10	13.7	81	12	14.8	52.4 ± 9.8	54.3 ± 10.2	60.1 ± 18.1	102.4 ± 43.1	92.5 ± 57.6
Total	2,339	225	9.6	232	30	12.9	232	36	15.5	119	22	18.5	123	22	17.9	53.8 ± 7.0	52.9 ± 6.9	72.3 ± 14.5	86.8 ± 28.4	103.4 ± 43.4
Walleye																				
2007	559	123	22.0	42	7	16.7	42	12	28.6	21	7	33.3	21	7	33.3	66.0 ± 11.8	66.0 ± 11.8	50.0 ± 10.1	85.7 ± 49.5	100.0 ± 75.8
2009	224	39	17.4	24	2	8.3	24	9	37.5	12	5	41.7	12	1	8.3	208.9 ± 71.1	69.6 ± 22.2	100.0 ± 59.8	450.0 ± 344.7	500.0 ± 521.6
Total	783	162	20.7	66	9	13.6	66	21	31.8	33	12	36.4	33	8	24.2	85.3 ± 13.3	68.3 ± 10.6	56.3 ± 10.1	131.3 ± 57.2	150.0 ± 86.8
Yellow perch																				
2009	379	61	16.1	40	7	17.5	40	11	27.5	20	3	15.0	20	8	40.0	40.2 ± 10.2	58.5 ± 14.8	43.8 ± 13.5	68.8 ± 41.3	37.5 ± 42.8
Grand total																				
	16,948	3,100	18.3	1,738	409	23.5	1,752	542	30.9	878	293	33.4	886	299	33.7	54.2 ± 1.9	54.5 ± 1.9	69.7 ± 2.7	91.7 ± 7.7	98.9 ± 11.3

[a]Based only on $200 tags as high rewards.
[b]Based on using $100 and $200 tags as high rewards.

one nonreward tag. The difficulty in evaluating independence of tag returns is that it is not possible to calculate reporting rates directly to test this assumption. That would require knowledge of the number of tags released to each of two groups, such as (1) anglers reporting more than one tag (and thus potentially biasing their reporting rate via batch reporting), and (2) anglers reporting only one tag. Obviously no such separation of tag releases can be made because tags are released to all anglers together. Instead, we used a contingency table and χ^2 test (at $\alpha = 0.05$) to assess the number of tags reported for each dollar amount between two groups, one being anglers who reported more than one tag from the same household and who therefore could have reported batches of tags, the other being anglers from the same household who reported only one tag. As a second evaluation of batch tag returns, we similarly tested for a difference between those anglers who reported both nonreward and reward tags, who also could have been reporting batches of tags, versus those who reported only one tag type or the other. If there were no differences between groups, then the estimated tag-reporting rates could not have been biased by batch reporting, although Pollock et al. (2001) pointed out that the CIs around the estimated reporting rates could be wider than those reported.

RESULTS

A total of 4,643 tags (21% of those released) were reported by anglers (Table 1). Tags were reported primarily via the tag-return phone number (mean = 53% of returned tags) or website (36%). Over the 4 years of the study, the proportion of tags reported by phone decreased from 62% to 48%, whereas tags reported via the website increased from 22% to 44%. A total of $120,290 was awarded to anglers over 4 years of tagging.

Site-specific estimates of nonreward tag reporting rate varied substantially, from a low of 34% to a high of 80%, but most estimates (72%) ranged from 40% to 70% (Table 1). Site-specific estimates were typically imprecise due to low sample sizes, with only 11 of 36 estimates having 95% confidence bounds that were less than 50% of the estimate. However, once pooled into groups of species and by year, estimates of nonreward tag reporting rates were much more precise (Table 2), 95% confidence bounds averaging only 17% of the estimates.

Reporting rates increased as the reward amount increased (Table 2). Assuming 100% reporting rates for \$200 dollar tags and pooling tags across all years and species, weighted reporting rates were 54.2 ± 1.9% (95% confidence interval) for nonreward tags, 69.7 ± 2.7% for \$10 tags, 91.7 ± 7.7% for \$50 tags, and 98.9 ± 11.3% for \$100 tags. Using \$100 and \$200 returns combined as high-reward tags (to improve sample size of high-reward returns), weighted mean reporting rate for nonreward tags was 54.5 ± 1.9%.

There did not appear to be any consistent pattern to differences in nonreward tag reporting rates between years (Table 2). For example, crappies and smallmouth bass reporting rates were both highest in the second year of tagging and lowest in the last year. For hatchery trout, reporting rate in year 1 was highest. Although reporting rates varied from year to year for each species, the 95% CIs for nonreward tag-reporting rates overlapped in all years for all species other than crappies in 2007 (74.0 ± 9.8%) and 2009 (48.2 ± 6.8%). Weighted mean nonreward tag-reporting rate for all species combined was 53% in 2006, 56% in 2007, 50% in 2008, and 56% in 2009.

Nonreward tag reporting rates (using \$100 and \$200 as high-reward tags) were consistently higher for harvest-oriented coolwater and warmwater fisheries (Table 2), such as for walleyes (68.3 ± 10.6%), crappies (59.7 ± 4.0%), and yellow perch (58.5 ± 14.8%). Tag reporting rate was lowest for largemouth bass (39.2 ± 6.2%).

We found some evidence of a slight violation in the assumption of independence of tag returns (Figure 1). Nonreward tags made up 73.0% and high-reward tags 10.8% of the tag returns for anglers who reported both reward and nonreward tags, compared with 67.7% and 11.8% for anglers reporting only one of the two tag types. This difference was considered marginally significant ($\chi^2 = 3.23$; $P = 0.07$), indicating that angler reporting rate may have been slightly higher when an angler was reporting both reward and nonreward tags versus anglers reporting only one or the other. Likewize, nonreward tags made up 69.0% and high-reward tags 11.3% of the tags reported by anglers or households who reported multiple tags, compared with 72.9% and 10.9% for anglers or households who reported only one tag; this difference was not statistically significant ($\chi^2 = 0.94$; $P = 0.33$).

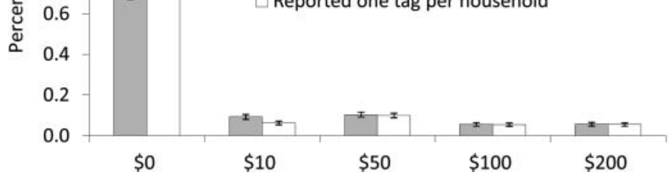

FIGURE 1. Percentage of tags reported (and 95% confidence intervals) by reward dollar amount for anglers who reported both reward and nonreward tags versus one or the other tag type (upper panel), or who reported multiple tags from the same household versus one tag only from a given household (lower panel).

DISCUSSION

Angler nonreward tag reporting rates across all study sites and species averaged about 55%, which is at the upper end of most values found in the fisheries literature. Previous estimates have ranged from a low of 15% to a high of 92%, but generally have been between 20% and 65% (Rawstron 1971; Moring 1980; Green et al. 1983; Colvin 1991; Larson et al. 1991; Maceina et al. 1998; Miranda et al. 2002; Schultz and Robinson 2002). Our average reporting rate was much higher than the estimated 32% for nonreward mallard band returns from the seminal study by Nichols et al. (1991). However, as with reporting rates from fisheries studies, other duck-banding reporting rates, as well as reporting rates for other studies of birds with a similar study design, have varied widely from 38% to 71% (Henny and Burnham 1976; Reeves 1979; Conroy and Blandin 1984; Nichols et al. 1995; Diefenbach et al. 2000). Taken collectively, these bird studies exhibited an average nonreward band reporting rate of 44%, which is close to our weighted mean of 55%. The similarity in the mean and range of reporting rates between bird hunters and anglers is not surprising considering that they are frequently the same people (e.g., Mehmood et al. 2003). The variability in reporting rates between bodies of water is probably due to several factors, such as differences in clientele and angler groups frequenting the body of water (Fisher 1997; Taylor et al. 2006), angler satisfaction with the fishery in general or the agency conducting the tagging program, differences in anglers' reward-tag-encounter rates caused by chance alone, and the geographical area where the tags are released (Conroy and Blandin 1984; Nichols et al. 1995). We believe the range of reporting rates in our study is probably representative of what should be expected for anglers in Idaho and elsewhere.

In most instances, site-specific reporting rates were imprecize due to the low number of returns of high-reward tags. Indeed, for 13 of the 45 attempts to estimate site-specific reporting rate, six or fewer high-reward tags (\$100 and \$200 combined) were reported. At such low numbers, estimates of nonreward tag-reporting rate can be changed substantially by the chance addition or subtraction of one high-reward tag. For example, nonreward tag reporting rate for walleyes in Oakley Reservoir in 2009 would have increased by 14 percentage points or decreased by 10 points by the chance addition or subtraction of one high-reward tag. This drastic effect of adding or subtracting one single high-reward tag return at low samples sizes, coupled with the already variable tag reporting rates between species and bodies of water, resulted in highly disparate nonreward tag reporting rates in our study, and precluded estimates from being made in many instances. For this reason, we suggest that if tags are being released in several bodies of water to estimate angler exploitation, then nonreward and high-reward tags should both be released, and weighted mean reporting rates should be calculated for all tags returned rather than relying solely on estimating tag reporting rates at individual bodies of water. As Pollock et al. (2001) pointed out, in a typical tagging study estimating survival or exploitation, the use of high-reward tags can be justified as cost-effective because the higher tag-return rates provide better estimates of survival or exploitation.

Nonreward tag reporting rates for coolwater and warmwater species were highest for harvest-oriented fish such as crappies, yellow perch, and walleyes, and were lowest for largemouth bass, for which many anglers currently are committed to voluntary catch-and-release angling (e.g., Myers et al. 2008). This suggests that anglers may be more likely to report tags from fish they intend to harvest, and may find tag removal more of a nuisance if they plan to release the fish. Moreover, although our tags were orange, algae sometimes obscured the tags over time, and anglers who were releasing their catch may have been less likely to see the tag attached to the fish. However, these explanations are not supported by results from coldwater anglers, for which reporting rates were similar for wild trout anglers (who were presumably more likely to release their catch) and hatchery trout. Green et al. (1983) found that tag reporting rates varied for several species, and between several different bays in Texas, but they did not assert a reason for these differences.

Our results suggest that between \$50 (92% estimated reporting rate) and \$100 (99%) was needed to elicit the maximum reporting rate from anglers. This agrees with Nichols et al. (1991) who also found an asymptote between \$50 and \$100 (1988 dollars) for mallard band returns, and with Taylor et al. (2006) who found an asymptote between \$75 and \$100 (1996 dollars) for tag returns of common snook *Centropomus undecimalis*. It appears that inflation in the last 15–20 years has not upwardly shifted the incentive needed to elicit the maximum reporting rate for tags in fisheries and wildlife studies.

One of our main concerns with the study design was violating the assumption that tag returns were independent, such as would happen if anglers reported batches of tags. The most likely way this could happen is if anglers held onto one or more nonreward tags without reporting them, but then reported them once they caught a reward tag. Our results suggest that this may have occurred in our study, but only to a slight degree. Another example is cumulative tag returns, where anglers might become more likely to report several nonreward tags than they would be for only one tag, but we saw no evidence of this in our study. Pollock et al. (2001) suggested the best way to avoid these types of bias is to disperse tags in a large number of locations so that an angler is not likely to encounter many tags. We spread more than 22,000 tags across 25 bodies of water using eight different species of fish over 4 years in an attempt to do this. However, when the ultimate goal is to obtain exploitation estimates at individual bodies of water (as was the case in this study), a high number of tags must be released at each location in a given year. For our study, this resulted in substantial angler catch inequality, in that 20% of the people (or households) reported about 43% of the tags. Such catch inequality is common in fisheries (e.g., Smith 1990; Baccante 1995; van Poorten and Post 2005; Michaletz et al. 2008). Fortunately, anglers reporting multiple tags or those reporting both nonreward and high-reward tags did not differ meaningfully in their tag reporting rate from anglers reporting only one tag or one type of tag. Based on these findings, we conclude that several hundred tags can probably be released in a particular body of water to estimate exploitation without being overly concerned that nonreward tag reporting rates will be skewed by the presence of a high number of tags or limited numbers of reward tags.

Despite this conclusion, caution should nevertheless be used to avoid overwhelming anglers with too many tags and risk reducing the average tag-reporting rate, which would result in biased exploitation rates if the reduction was not monitored over time. Henny and Burnham (1976) found that reporting rates for nonreward duck bands declined 10% over 16 years, the decline being related to the number of tags released in a local area, and they concluded that hunters became “swamped” with tags, causing curiosity to wane over time. In our study, nonreward tag reporting rate did not appear to decline over time except for a few species (e.g., crappies and perhaps smallmouth bass). Moreover, the weighted mean nonreward reporting rate remained virtually unchanged over time, and subsequent tagging in later years (K. Meyer, unpublished data) suggests no decline in reporting rate (as of 2011). Nevertheless, declines can probably be expected if tags are continually released to estimate exploitation, and the best way to monitor whether this happens is to release a small number of reward tags each year that nonreward tags are released so that nonreward reporting rate can be estimated annually.

Another concern was that having reward tags at liberty in a fishery might alter angler behavior and ultimately lead to inaccurate estimates of exploitation. For example, some anglers reported that people were fishing (and therefore potentially harvesting fish) largely because of the reward program (i.e., fishing for reward dollars). There may also have been some confusion by anglers as to whether or not nonreward tags would result in a reward after the report was made (Pollock et al. 2001). We attempted to control for these potential sources of bias by not advertising tag releases at any particular bodies of water, and instead used statewide education (with informational stickers and posters placed at fishing license venders) to draw attention to the overall program. Thus, we believe these limitations probably had little impact on the results of our study.

Managers attempting to estimate angler tag-reporting rates for studies of fish survival or exploitation must consider the tradeoffs of accuracy and precision, balancing the sample size limitations of estimating site-specific tag-reporting rates with the applicability of using a mean tag-reporting rate across several bodies of water but knowing that the reporting rate may vary between locations. The confidence bounds using a mean tag-reporting rate will be smaller than for estimates of a site-specific rate, but because of the variability in reporting rates between sites and species, a point estimate may be more accurate (although less precise) when site-specific estimates are available via releasing comingled high-reward and nonreward tags in a particular body of water for a particular species of fish. More research would help clarify differences in reporting rates between species and over a prolonged period, and the results of Henny and Burnham (1976) suggest that continued release of some high-reward tags would help calibrate tag-reporting rates over time as anglers become more exposed (and potentially more apathetic) to tagged fish.

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REFERENCES

Baccante, D. 1995. Assessing catch inequality in walleye angling fisheries. North American Journal of Fisheries Management 15:661–665.

Colvin, M. A. 1991. Population characteristics and angler harvest of white crappies in four large Missouri reservoirs. North American Journal of Fisheries Management 11:572–584.

Conroy, M. J., and W. W. Blandin. 1984. Geographic and temporal differences in band reporting rates for American black ducks. Journal of Wildlife Management 48:23–36.

Diefenbach, D. R., C. F. Riegner, and T. S. Hardisky. 2000. Harvest and reporting rates of game-farm ring-necked pheasants. Wildlife Society Bulletin 28:1050–1059.

Eder, S. 1990. Angler use of black crappie and the effects of a reward-tag program at Jamesport Community Lake, Missouri. Pages 647–654 *in* N. C. Parker, A. E. Giorgi, R. C. Heidinger, D. B. Jester Jr., E. D. Prince, and G. A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Fisher, M. R. 1997. Segmentation of the angler population by catch preference, participation, and experience: a management-oriented application of recreation specialization. North American Journal of Fisheries Management 17:1–10.

Green, A. W., G. C. Matlock, and J. E. Weaver. 1983. A method for directly estimating the tag-reporting rate of anglers. Transactions of the American Fisheries Society 112:412–415.

Guy, C. S., H. L. Blankenship, and L. A. Nielsen. 1996. Tagging and marking. Pages 353–383 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Haas, R. C. 1990. Effects of monetary rewards and jaw-tag placement on angler reporting rates for walleyes and smallmouth bass. Pages 655–659 *in* N. C. Parker, A. E. Giorgi, R. C. Heidinger, D. B. Jester Jr., E. D. Prince, and G. A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Henny, C. J., and K. P. Burnham. 1976. A reward band study of mallards to estimate reporting rates. Journal of Wildlife Management 40:1–14.

Jenkins, W. E., M. R. Denson, and T. I. J. Smith. 2000. Determination of angler reporting level for red drum (*Sciaenops ocellatus*) in a South Carolina estuary. Fisheries Research 44:273–277.

Larson, S. C., B. Saul, and S. Schleiger. 1991. Exploitation and survival of black crappies in three Georgia reservoirs. North American Journal of Fisheries Management 11:604–613.

Maceina, M. J., P. W. Bettoli, S. D. Finely, and V. J. DiCenzo. 1998. Analyses of the sauger fishery with simulated effects of a minimum size limit in the Tennessee River of Alabama. North American Journal of Fisheries Management 18:66–75.

Mehmood, S., D. Zhang, and J. Armstrong. 2003. Factors associated with declining hunting license sales in Alabama. Human Dimensions of Wildlife 8:243–262.

Michaletz, P. H., M. J. Wallendorf, and D. M. Nicks. 2008. Effects of stocking rate, stocking size, and angler catch inequality on exploitation of stocked channel catfish in small Missouri impoundments. North American Journal of Fisheries Management 28:1486–1497.

Miranda, L. E., R. E. Brock, and B. S. Dorr. 2002. Uncertainty of exploitation estimates made from tag returns. North American Journal of Fisheries Management 22:1358–1363.

Moring, J. R. 1980. Nonreporting of recaptures of tagged rainbow trout from an Oregon stream. Progressive Fish-Culturist 42:113–115.

Murphy, M. D., and R. G. Taylor. 1991. Preliminary study of the effect of reward amount on tag-return rate for red drums in Tampa Bay, Florida. North American Journal of Fisheries Management 11:471–474.

Myers, R., J. Taylor, M. Allen, and T. F. Bonvechio. 2008. Temporal trends in voluntary release of largemouth bass. North American Journal of Fisheries Management 28:428–433.

Nichols, J. D., R. J. Blohm, R. E. Reynolds, R. E. Trost, J. E. Hines, and J. P. Bladen. 1991. Band reporting rates for mallards with reward bands of different dollar values. Journal of Wildlife Management 55: 119–126.

Nichols, J. D., R. E. Reynolds, R. J. Blohm, R. E. Trost, J. E. Hines, and J. P. Bladen. 1995. Geographic variation in band reporting rates for mallards based on reward banding. Journal of Wildlife Management 59:697–708.

Nielsen, L. A. 1992. Methods of marking fish and shellfish. American Fisheries Society, Special Publication 23, Bethesda, Maryland.

Pine, W. E., K. H. Pollock, J. E. Hightower, T. J. Kwak, and J. A. Rice. 2003. A review of tagging methods for estimating fish population size and components of mortality. Fisheries 28(10):10–23.

Pollock, K. H, J. M. Hoenig, W. S. Hearn, and B. Calingaert. 2001. Tag reporting rate estimation: 1. an evaluation of the high-reward tagging method. North American Journal of Fisheries Management 21:521–532.

Rawstron, R. R. 1971. Nonreporting of tagged white catfish, largemouth bass, and bluegills by anglers at Folsom Lake, California. California Fish and Game 57:246–252.

Reeves, H. M. 1979. Estimates of reporting rates for mourning dove bands. Journal of Wildlife Management 43:36–42.

Ryan, P. M. 1990. Sizes, structures, and movements of brook trout and Atlantic salmon populations inferred from Schnabel mark–recapture studies in two Newfoundland lakes. Pages 725–735 *in* N. C. Parker, A. E. Giorgi, R. C. Heidinger, D. B. Jester Jr., E. D. Prince, and G. A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Schultz, R. D., and D. A. Robinson Jr. 2002. Exploitation and mortality rates of white bass in Kansas reservoirs. North American Journal of Fisheries Management 22:652–658.

Smith, C. L. 1990. Resource scarcity and inequality in the distribution of catch. North American Journal of Fisheries Management 10: 269–278.

Taylor, R. G., J. A. Whittington, W. E. Pine III, and K. H. Pollock. 2006. Effect of different reward levels on tag reporting rates and behavior of common snook anglers in southeast Florida. North American Journal of Fisheries Management 26:645–651.

van Poorten, B. T., and J. R. Post. 2005. Seasonal fishery dynamics of a previously unexploited rainbow trout population with contrasts to established fisheries. North American Journal of Fisheries Management 25: 329–345.

Vreeland, R. R. 1990. Random-sampling design to estimate hatchery contributions to fisheries. Pages 691–707 *in* N. C. Parker, A. E. Giorgi, R. C. Heidinger, D. B. Jester Jr., E. D. Prince, and G. A. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Weaver, O. R., and R. H. England. 1986. Return of tags with different rewards in Lake Lanier, Georgia. North American Journal of Fisheries Management 6:132–133.