# Tag-reporting levels for red drum (*Sciaenops ocellatus*) caught by anglers in South Carolina and Georgia estuaries*

**Michael R. Denson**
**Wallace E. Jenkins**
Marine Resources Research Institute
South Carolina Department of Natural Resources
217 Ft. Johnson Rd.
Charleston, South Carolina 29422-2559
E-mail address (for W. E. Jenkins, contact author): jenkinsw@mrd.dnr.state.sc.us

**Arnold G. Woodward**
Coastal Resources Division
Georgia Department of Natural Resources
1 Conservation Way
Brunswick, Georgia 31523

**Theodore I. J. Smith**
Marine Resources Research Institute
South Carolina Department of Natural Resources
P.O. Box 12559
217 Ft. Johnson Rd.
Charleston, South Carolina 29422-2559

**Abstract**—A total of 1784 legal-size (≥356 mm TL) hatchery-produced red drum (*Sciaenops ocellatus*) were tagged and released to estimate tag-reporting levels of recreational anglers in South Carolina (SC) and Georgia (GA). Twelve groups of legal-size fish (~150 fish/group) were released. Half of the fish of each group were tagged with an external tag with the message "reward" and the other half of the fish were implanted with tags with the message "$100 reward." These fish were released into two estuaries in each state (*n*=4); three replicate groups were released at different sites within each estuary (*n*=12). From results obtained in previous tag return experiments conducted by wildlife and fisheries biologists, it was hypothesized that reporting would be maximized at a reward level of $100/tag. Reporting level for the "reward" tags was estimated by dividing the number of "reward" tags returned by the number of "$100 reward" tags returned. The cumulative return level for both tag messages was 22.7 (±1.9)% in SC and 25.8 (±4.1)% in GA. These return levels were typical of those recorded by other red drum tagging programs in the region. Return data were partitioned according to verbal survey information obtained from anglers who reported tagged fish. Based on this partitioned data set, 14.3 (±2.1)% of "reward" tags were returned in SC, and 25.5 (±2.3)% of "$100 reward" tags were returned. This finding indicates that only 56.7% of the fish captured with "reward" tags were reported in SC. The pattern was similar for GA where 19.1 (±10.6)% of "reward" message tags were returned as compared with 30.1 (±15.6)% for "$100 reward" message tags. This difference yielded a reporting level of 63% for "reward" tags in GA. Currently, 50% is used as the estimate for the angler reporting level in population models for red drum and a number of other coastal finfish species in the South Atlantic region of the United States. Based on results of our study, the commonly used reporting estimate may result in an overestimate of angler exploitation for red drum.

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There are major marine recreational fisheries along the south Atlantic and Gulf of Mexico coasts of the United States that target red drum, *Sciaenops ocellatus* (Matlock, 1986a; 1986b). During the late 1980s, overexploitation of red drum in many states resulted in the closure of commercial fisheries in most states and in the imposition of creel and size limits on catch of recreational anglers (McGurrin[1]) Concurrently, studies were initiated in a number of coastal states to gain a better understanding of red drum life history and to attempt to estimate exploitation rates. These investigations relied heavily on the use of fishery-dependent, mark-recapture studies to obtain the data necessary for creating a robust population model (McGurrin[1]).

Generic population models have been developed by using mark-recapture studies to estimate expected number of animals that survive and are recaptured from a year class within a given year (Brownie et al., 1985). Pollock et al. (1991) emphasized the need to modify tag recovery models in which data from multiyear tagging studies were used and suggested incorporating variables for postmarking survival and for reporting to estimate the recapture component of the model more accurately. The current model used to estimate recovery (recapture) rates of tagged fish ($\theta$) includes a number of variables in an attempt to accurately account for what happens in nature ($\theta=\phi\mu\lambda$), where $\phi$ = tag retention multiplied by fish survival after tagging; $\mu$ = exploitation rate; and $\lambda$ = reporting level (Hoenig et al., 1998). Reporting level ($\lambda$) of tagged fish captured by anglers is perhaps the most difficult variable to estimate accurately and is often assumed to be constant over time and geographic area (Hoenig et al., 1998).

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[1] McGurrin J. 1991. Fisheries management report 19 of the Atlantic States Marine Fisheries Commission. Fishery management plan for red drum—amendment 1, 123 p. Atlantic States Marine Fisheries Commission, 1400 16th St. NW Suite 310, Washington, D.C. 20036.

If the level of reporting can be closely estimated, then this estimated value can be incorporated into models that more accurately estimate survival and escapement (Hoenig et al., 1998).

In the past, researchers have attempted to accurately estimate reporting for marked animals in a number of ways. Some resource agencies have had creel clerks secretly implant tags into recreational anglers' creel during interviews, and others have conducted formal reward studies. For example, in Texas (TX), recreational anglers reported only 28% of a number of species of estuarine and marine finfish surreptitiously tagged by creel clerks (Matlock, 1981). A small-scale study during which red drum were surreptitiously tagged in Georgia (GA) also revealed low reporting levels (55%)(Woodward[2]). The GA study also noted trends in reporting by county and income level; however, because the number of tagged fish and subsequent returns in this study were small, valid statistical comparisons could not be made (Woodward[2]). Rawstron (1971) in a similar, more robust investigation conducted in freshwater lakes, found reporting levels of 50% for tagged bluegill, largemouth bass, and catfish and concluded that reporting appeared to be site and species specific.

Cash reward values ≤$50 have been used by many tagging programs to assess reporting levels (Rawstron, 1971; Matlock, 1981; Murphy and Taylor, 1991). In most cases, results have suggested that small cash awards do not provide adequate incentive for anglers to report capture of a tagged fish (Rawstron, 1971; Matlock, 1981; Murphy and Taylor, 1991). Work in California with stocked trout showed significantly higher reporting when a reward was offered, rather than no reward (Butler, 1962). Butler concluded that variability in reporting was also related to a number of other factors, including degree of publicity, angler interest in the fishery, and effort made to recover tags. Difficulty in determining reporting is not unique to fisheries population modeling. Historically, bands have been used to monitor populations of waterfowl and other birds. Reporting of banded waterfowl has also been shown to differ between locations (Henny and Burnham, 1976; Conroy and Blandin, 1984). For example, in areas where merchandise was regularly offered for banded birds, reporting decreased as compared with areas where capture of a marked bird was simply a novelty (Conroy and Blandin, 1984). Reward studies have attempted to overcome these problems by offering higher monetary rewards. In a study with waterfowl where rewards ranged from $5 to $1000, Nichols et al. (1991) demonstrated that there was a correlation between reporting and reward value. They also determined the asymptote for 100% reporting by duck hunters occurred between a reward value of $75 and $100. In a study of red drum in South Carolina (SC), Jenkins et al. (2000) found that $50 was not a high enough value to result in reporting differences between the standard "reward" message and a "$50 reward" message.

[2] Woodward, A. G. 1992. Evaluation of fish tag reporting by marine boat anglers in Georgia, 12 p. Georgia Department of Natural Resources, Coastal Resources Division, 1 Conservation Way, Brunswick, GA 31523.

For modeling purposes fishery managers in the south Atlantic region of the United States use reporting estimates of ~50% when analyzing return data for red drum. This approximate figure is used even though previous studies have shown that a number of variables may affect the accuracy of reporting tagged animals (Butler, 1962; Rawstron, 1971; Nichols et al., 1991; Ross et al., 1995; Woodward[2]). Assigning an approximate reporting level for the entire region could introduce bias in estimates of exploitation and potentially lead to significant exploitation of the population being managed. In previous studies where reporting levels for red drum and other finfish species were examined, there were a limited number of experimental units, making robust statistical analyses of the data difficult (Murphy and Taylor, 1991; Woodward[2]). This shortcoming is primarily due to logistical problems associated with capture, tagging, and release of sufficient numbers of similar-size wild fish in a manner that will ensure equal vulnerability to anglers over a large area (Yeager and Van Den Avyle, 1979; Murphy and Taylor, 1991). Our study attempts to reduce these problems by using similar-size hatchery-produced fish to carry tags. This experimental model allows a high degree of control over the design and implementation of a study (Jenkins et al., 2000). Further, fish can be tagged and stocked during seasons of the year when angler pressure is high, thereby minimizing the time required for data acquisition, as well as reducing variability associated with seasonal fluctuations in fishing effort (Jenkins et al., 2000). To assess the veracity of the currently used reporting estimate, a study was conducted in two estuaries in SC and two in GA. It was expected that the information obtained would provide a more accurate estimate for use in modeling red drum population dynamics in the south Atlantic region.

## Materials and methods

All fish used in our study were progeny of locally captured wild broodstock. Adults had been spawned in tanks by using photoperiod and thermal conditioning (Roberts et al., 1978) at the SC Department of Natural Resources (SCDNR), Marine Resources Research Institute (MRRI) in Charleston, SC. Three day-old larvae were stocked in ponds at the SCDNR's Waddell Mariculture Center (WMC) in Bluffton, SC. When fish had grown to a mean total length (TL) of 200 mm, they were harvested and transported to MRRI. At MRRI, fish were grown to legal size (356 mm TL) in 4-m diameter tanks.

When fish were legal size (or approximately legal size), they were anesthetized in groups in a 0.1-g/L solution of MS-222 and culture water. Fish were then individually measured to the nearest mm and tagged with abdominal anchor tags (Floy Tag and MFG Co., Inc., Seattle, WA). In an effort to obtain results consistent with those from ongoing mark recapture programs in each state, fishery biologists from SC and GA tagged the fish to be stocked in their respective state. In addition, the tags used were identical to those used in ongoing studies in each state. For SC releases Floy model FM-95W tags were used.

These tags were completely orange and consisted of two parts: a 6.4-mm × 25.4-mm laminated disk wired to a 75-mm laminated streamer. The streamer portion contained the words "tag inside," a tag number, name of agency, and the reward message ("reward" or "$100 reward"). The disk portion contained the return address, reward message, a unique tag number, and the following: "reward, send tag, date, location, gear, length, phone number to …". Tags used in GA tags were also Floy tags (model FM-89SL). As in SC, the tag consisted of two parts. The laminated disk was slightly smaller (6.4 mm × 19 mm) and yellow, whereas the streamer was the same length (75 mm) and was the same color (orange) used for fish released in SC. The streamer did not contain the words "tag inside" but it did contain the rest of the information found on the SC streamers plus "return to…". The disk portion contained much of the same information found on the SC disk except "reward, send tag, date, location, gear, length, phone number to …". One half of the tags deployed in each state contained the message "$100 reward"; the remainder contained the message "reward." The "reward" message is the standard message that has been used for over 10 years in red drum mark-recapture studies in each state. Because of limitations in project funding and duration, the "$100 reward" tags also had an expiration date; "reward" tags, however, did not have an expiration date.

After having been tagged, fish were retained in culture tanks for a minimum of one week to recover from handling. In preparation for release, marked fish were removed from the tanks and transported in oxygenated water, at a biomass density of ≤50 g/L, to the preselected estuaries. The estuaries in each state were as follows: Charleston Harbor and Calibogue Sound in SC; St. Simons Sound and Wassaw Sound in GA (Fig. 1). Three replicate release sites within each estuary were stocked with tagged fish. Upon arrival at each estuary, fish were acclimated for 1 hour to ambient water conditions prior to being transferred to holding tanks in boats. Within each estuary, the selected stocking sites had similar habitat characteristics and were geographically separate (≥5 km). At each site, fish were released individually approximately every 20 meters along the edge of the salt marsh to minimize the possibility of schooling behavior and subsequent multiple captures by individual anglers.

A total of 1774 fish were tagged and released during the project. Approximately 150 fish were released at each stocking site within each estuary (Table 1). Equal numbers of fish released at each site contained "reward" or "$100 reward" tags. Fish were released into Charleston Harbor, SC, and St Simons Sound, GA, during the fall of 1996 and into Calibogue Sound, SC, and Wassaw Sound, GA, during late spring and early summer 1997 (Table 1, Fig. 1). The expiration date for "$100 reward" tags deployed in fall 1996 was 31 March 1997, and for spring and summer 1997 releases, the expiration date was 31 December 1997. Neither the study nor the releases were publicized in any way other than by the normal information provided by ongoing tagging programs in each state. Captured tagged fish were reported directly to the respective Department of Natural Resources in each state. Participants who returned tags inscribed with "reward" received a prize that would normally be awarded by each agency (e.g. T-shirt or hat) and those reporting a "$100 reward" tag received a state-issued check for that amount.

Our study was based on two assumptions: 1) $100 was an adequate incentive to maximize reporting (assumed ~100%) of captured tagged fish; 2) the quotient of returns (the number of "reward"-inscribed tags divided by the returns of "$100 reward" tags) would yield the angler reporting level ($\lambda$) for the standard "reward" tag. Tags were returned in either of two ways: phone message or mail. All anglers who reported tags were later interviewed. During the interviews respondents were asked to confirm their reporting information and to express their attitudes and

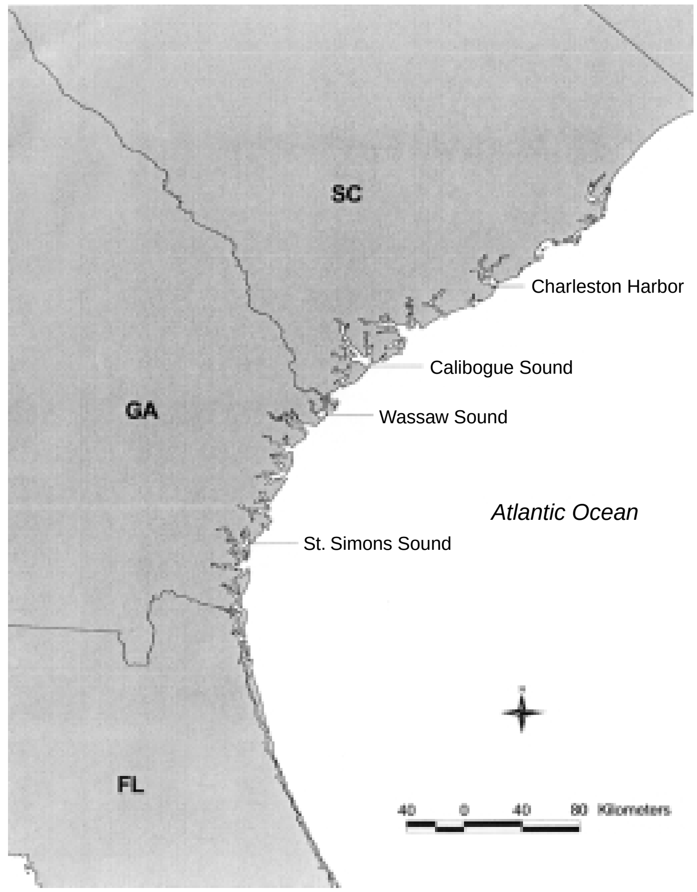


**Figure 1**

Map of coastal South Carolina (SC), Georgia (GA), and north Florida (FL) showing the location of each estuary where tagged red drum were released during the reward study.

**Table 1**

Cumulative data on release locations and stocking dates for fish, and both number of tags released and returned for each reward message.

| | | Tag | | | |
|---|---|---|---|---|---|
| | | "Reward" | | "$100 reward" | |
| Release location | Stocking date | No. released | No. returned | No. released | No. returned |
| Charleston Harbor | | | | | |
| site 1 | 31 Oct 1996 | 75 | 16 | 75 | 21 |
| site 2 | 31 Oct 1996 | 75 | 18 | 75 | 21 |
| site 3 | 31 Oct 1996 | 75 | 18 | 75 | 16 |
| St. Simons Sound | | | | | |
| site 1 | 13 Nov 1996 | 75 | 10 | 75 | 17 |
| site 2 | 13 Nov 1996 | 74 | 11 | 74 | 11 |
| site 3 | 13 Nov 1996 | 75 | 10 | 75 | 15 |
| Wassaw Sound | | | | | |
| site 1 | 8 May 1997 | 73 | 31 | 73 | 42 |
| site 2 | 8 May 1997 | 75 | 23 | 75 | 29 |
| site 3 | 8 May 1997 | 68 | 10 | 68 | 18 |
| Calibogue Sound | | | | | |
| site 1 | 5 Jun 1997 | 75 | 9 | 75 | 21 |
| site 2 | 9 Jul 1997 | 73 | 19 | 73 | 23 |
| site 3 | 10 Jul 1997 | 74 | 9 | 74 | 12 |

opinions about the reporting procedure. All participants were asked the same questions from a standardized survey script. During the interview no information was provided to the anglers about the study design.

For statistical analysis each release site was treated as a replicate. By nesting site within estuary, within state, differences associated with each site, estuary, and state could be treated in the analysis to assess influence of the reward messages. The study design was a 2×2 factorial design (state and reward) with three levels of nesting (state, estuary, and site) (Table 1). Owing to differences in growth rates, insufficient numbers of legal-size fish were available to stock all estuaries during the same month. Thus one estuary in each state was stocked in the fall of 1996 and the remaining estuaries were stocked the following spring and summer. However, each stocking group was available for capture during the fall season when fishing pressure is heaviest (Wenner[3]). Percent return data were arcsine square-root transformed prior to analysis. Return data were analyzed by using a two-way analysis of variance (ANOVA) with significance determined at $P \leq 0.05$. The initial analysis examined all reported or "cumulative" data. The data were then partitioned in two additional ways: by single returns and survey data.

### Single returns

This data set was the most restrictive. The assumption was that the partitioned data would be free of any potential bias associated with captures of multiple fish, or with monetary rewards or interactions with project staff.

### Survey data

The data were partitioned according to the angler's answers during the interview to determine whether the inducement of a $100 dollar reward changed his or her reporting behavior. This data set included all tags reported individually, all tags of the same message reported as multiples, and all $100 tags. However, it excluded "reward" tags in instances where answers during the interview suggested that the angler's behavior had been changed by capturing a fish with a "$100 reward" tag.

Mean data for each of these analyses were reported with standard errors.

## Results

Nearly 95% of tags that were returned were reported within 160 days after release of fish. More fish with "reward" tags were reported than those with "$100 reward" tags in one of the 12 release sites. Overall in SC, 151 anglers reported capture of 203 fish with tags. Anglers reported capture of 1–9 red drum per trip. One hundred

[3] Wenner, C. 1997. Personal commun. South Carolina Department of Natural Resources, 217 Ft. Johnson Rd. Charleston, SC 29422-2559.

and nineteen anglers in SC (79.0% of total anglers) reported only one tagged fish during the study. In GA, 184 anglers reported capture of 226 tagged fish. Single reports in GA represented 80.4% ($n$=148) of the total catch of tagged fish. The overall return level for all fish reported in SC (22.7 [±1.8]%) was not significantly different from that in GA (25.8 [±4.1]%) ($P$=0.8129, $F$=0.07) (Table 2). For the cumulative data, no significant differences were detected between "$100 reward" (27.8 [±3.3]%) and "reward" tags (20.8 [±2.7]%) ($P$=0.0724, $F$=12.33) (Table 2). There were also no statistical differences in the cumulative data among the estuaries within states ($P$=0.0604, $F$=4.07) (Table 2) and no detectable interaction between state and reward or reward and estuary within states, from the high variability in the cumulative data among estuaries and sites (52.5% and 47.5% of total variation, respectively).

## Single returns

To further restrict the potential for bias caused by interaction of different reward messages or caused by the project biologist, capture reports were partitioned to include instances where an angler returned only one tag during the entire study. Overall, no significant differences ($P$=0.1215, $F$=6.76) were detected between the single returns of "reward" (11.6 [±1.1]%) and "$100 reward" (15.0 [±2.5]%) treatments within SC. This was also the case in GA ($P$=0.1215, $F$=6.760 where 15.1(±2.9)% of "reward" tags were returned, as compared with 17.6 (±2.7)% for "$100 reward" tags (Table 3). In addition, when data were compared between states, no differences were detected ($P$=0.6152, $F$=0.35). However, when single returns among estuaries were compared, Wassaw Sound in GA (Fig. 1) yielded significantly higher returns ($P$=0.0126, $F$=7.95) than any of the other estuaries where fish were released (Table 3).

## Survey data

In SC, 52% of respondents indicated that they had previously caught tagged fish. Of those, several anglers admitted that they had not routinely reported tags. Additionally, others (16%) indicated that they would not have reported the tag if it had not been worth $100. In one extreme case an angler who reported six "$100 reward" tags and an equal number of "reward" tags at once, indicated that he would not have turned in an individual "$100 reward" tag because in his words "he did not need the money."

In GA, 29% of anglers had caught a tagged fish prior to the study; however only 7 (5%) said that they would not turn in tags worth less than $100. In light of this information, the return data were partitioned to eliminate potential bias that would result from encountering a "$100 reward" tag. This partitioned data set revealed that significantly fewer ($P$=0.0310, $F$=30.81) unbiased "reward" tags (14.3 [±2.1]%) were returned in SC than "$100 reward" tags (25.5 [±2.3]%) (Table 4). This was also true in GA, where 19.1(±4.3)% of "reward" tags were unbiased returns, as compared with 30.1 (±6.4)% of "$100 reward" tags ($P$=0.0310, $F$=30.81) (Table 4).

**Table 2**

Cumulative mean return level (%) and standard error for red drum tagged with one of two reward messages ("reward" or "$100 reward"). No significant differences were detected between reward message, estuary, or state.

| | Return level | |
|---|---|---|
| Release location | "Reward" (%) | "$100 reward" (%) |
| Charleston Harbor | 23.1 ±0.9 | 25.8 ±2.2 |
| Calibogue Sound | 16.7 ±4.7 | 25.2 ±4.6 |
| South Carolina (mean) | 19.9 ±2.6 | 25.5 ±2.3 |
| St. Simons Sound | 13.9 ±0.6 | 19.2 ±2.2 |
| Wassaw Sound | 29.3 ±8.0 | 40.9 ±9.0 |
| Georgia (mean) | 21.6 ±5.0 | 30.1 ±6.4 |
| Overall mean | 20.8 ±2.7 | 27.8 ±3.3 |

**Table 3**

Mean tag return level (%) and standard error for red drum tagged with one of two reward messages ("reward" or "$100 reward"). There were no significant differences in return levels by reward message within or among estuaries with the exception of those from Wassaw Sound which were significantly higher ($P$<0.05 noted by *) for both reward messages than any other estuary. SC = South Carolina; GA = Georgia.

| | Tag message | |
|---|---|---|
| Release location | "Reward" (%) | "$100 reward" (%) |
| Charleston Harbor, SC | 13.3 ±1.6 | 15.1 ±5.3 |
| Calibogue Sound, SC | 9.9 ±1.0 | 14.8 ±2.0 |
| South Carolina (mean) | 11.6 ±1.1 | 15.0 ±2.9 |
| St. Simons Sound, GA | 9.9 ±1.6 | 13.0 ±1.6 |
| Wassaw Sound, GA | 20.2 ±3.8* | 22.1 ±3.7* |
| Georgia (mean) | 15.1 ±2.9 | 17.6 ±2.7 |
| Overall mean | 13.3 ±1.6 | 16.3 ±1.8 |

## Discussion

Overall return levels for the tagged fish released in our study were similar to levels of angler return for red drum in each state's fishery-dependent tagging programs (Wenner[3], Woodward[4]). Because of high variability within estuaries, there were no significant differences between returns of "reward" and "$100 reward" according to the analysis of cumulative return data. The high variability

[4] Woodward, A. G. 1997. Personal commun. Georgia Department of Natural Resources, 1 Conservation Way, Brunswick, GA 31523.

**Table 4**

Mean return level (%), standard error, and range for unbiased data (adjustments based on verbal interviews) for red drum tagged with one of two reward messages ("reward" or "$100 reward"). Return data for the "$100 reward" message were significantly higher ($P<0.05$) for each estuary, state, and overall than those for the "reward" message.

| | Tag message | | Unbiased reporting level[1] (%) | |
|---|---|---|---|---|
| Release location | "Reward" (%) | "$100 reward" (%) | Mean | Range |
| Charleston Harbor | 17.3 ±1.3 | 25.8 ±3.9 | 67.1 | 57–78 |
| Calibogue Sound | 11.3 ±6.3 | 25.2 ±8.0 | 44.8 | 19–67 |
| South Carolina (mean) | 14.3 ±5.2 | 25.5 ±5.6 | 56.7 | — |
| St. Simons Sound | 11.7 ±2.1 | 19.2 ±3.9 | 60.9 | 41–82 |
| Wassaw Sound | 26.5 ±10.4 | 40.9 ±15.7 | 64.8 | 56–79 |
| Georgia (mean) | 19.1 ±10.6 | 30.1 ±15.6 | 63.4 | — |
| Overall mean | 16.7 ±6.2 | 27.8 ±11.5 | 60.1 | 19–82 |

[1] Example: Charleston Harbor: "$100 reward" tags reported = 100%: 17.3/25.8 = 67.1% reporting level for "reward" tags.

between sites within the same estuary was unexpected. In addition, variation between estuaries in the same state made comparisons between states difficult. However, "reward" tags were returned less often than "$100 reward" tags from 11 of the release sites in the unpartioned data set. After identifying and excluding possible sources of bias, we found that there were statistically significant differences between reporting level of "reward" and "$100 reward" tags in all areas (Table 4). The range of 19–82% in levels of reporting between sites was more variable than anticipated (Table 4). Removal of the suspected biased anglers from the data set resulted in a mean unbiased reporting level of 67.1% in Charleston Harbor and 44.8% in Calibogue Sound (Table 4). Unbiased reporting in GA was somewhat higher than in SC (63.4% vs. 56.7%). The fact that significant differences were found only after biased angler data were removed from the data set illustrates that a small number of skilled anglers can have an effect on fisheries-dependent data. Their failure to report tags may be due to a lack of novelty in encountering tagged fish, or to insufficient reward incentives (having already received a number of t-shirts, fishing caps, etc.). These data suggest that use of noncash rewards is beneficial only for the first time an angler catches a tagged fish and decreases as anglers catch additional tagged fish. Further repeated exposure to tagging programs within each state eventually results in angler ambivalence and reduced cooperation. This indifference is of particular concern with the use of a constant regional reporting rate as described by Hoenig et al. (1998). A decreasing rate of tag return could be mistaken for lower harvest, reduced fishing effort, poor survival, or increased population size.

Lack of differences in reporting levels between "reward" and "$100 reward" in the single-return (one fish) partition of data (Table 3) confirms that anglers who capture many tagged fish per trip or per season (who were omitted from this data set) significantly influence reporting. Single return-data also suggest that anglers who catch fewer fish (tagged or not tagged) are more likely to report captures of tagged fish regardless of reward amount. Considering the impact a few skilled anglers can have on tag reporting estimates, these results demonstrate the need for further evaluation of the interaction between tagging programs and angler behavior. The 50% reporting level currently used by managers is approximately a 17% underestimate (50/60=0.83) of actual reporting recorded for the red drum fishery in SC and GA. Continuing to use the 50% reporting estimate for this fishery will be more conservative than using the actual reporting level ($\lambda$) to calculate angler recovery rate ($\theta$). Reporting was also extremely site specific, and application of data from one site to a broader area may not be appropriate. Ideally tag-recapture models should be weighted by site-specific reporting information to account for this variability which could be accomplished by regular deployment of high value (≥$100) reward tags within each system to gauge angler reporting. Even if offering a $100 does not result in 100% reporting, as Nichols et al. (1991) suggested, it may yield the highest reporting possible with monetary incentives, meaning that our unbiased reporting may have been slightly overestimated. Regardless, this approach is still more accurate than that of adopting a regional average. Our results emphasize that researchers need to conduct controlled tag reward studies regularly and also to offer sufficient rewards in order to avoid under reporting. Furthermore, tag reports must be followed up with angler interviews to determine attitudes and give managers an opportunity to remove bias from the data (Reinecke et al., 1992, Zale and Bain, 1994, Pegg et al., 1996).

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## Literature cited

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson.
1985. Statistical inference from band recovery data: a handbook, 2nd ed. U.S. Fish and Wildl. Serv. Resour. Publ. 156, 305 p..

Butler, L.
1962. Recognition and return of trout tags by California anglers. Calif. Fish Game 48:5–18.

Conroy, M. J., and W. W. Blandin.
1984. Geographical and temporal differences in band reporting rates for American black ducks. J. Wildl. Manage. 48:23–36.

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

Hoenig, J. M., N. J. Barrowman, K. H. Pollock, E. N. Brooks, W. S. Hearn, and T. Polacheck.
1998. Models for tagging data that allow for incomplete mixing of newly tagged animals. Can. J. Fish. Aquat. Sci. 55:1477–1483.

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. Fish. Res. 44:273–277.

Matlock, G. C.
1981. Non-reporting of recaptured tagged fish by saltwater recreational boat anglers in Texas. Trans. Am. Fish. Soc. 110:90–92.
1986a. Estimate of the number of red drum anglers in Texas. N. Am. J. Fish. Manage. 6:292–294.
1986b. Estimating the direct market economic impact of sport angling for red drum in Texas. N. Am. J. Fish. Manage. 6:490–493.

Murphy, M. D., and R. G. Taylor.
1991. Preliminary study of the effect of reward amount on tag-return rate for red drum in Tampa Bay, Florida. N. Am. J. Fish. Manage. 11:471–474.

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

Pegg, M. A., J. B. Layzer, and P. W. Bettoli.
1996. Angler exploitation of anchor-tagged saugers in the lower Tennessee River. N. Am. J. Fish. Manage. 16:218–222.

Pollock, K. H., J. M. Hoenig and C. M. Jones.
1991. Estimation of fishing and natural mortality when a tagging study is combined with a creel survey or port sampling. Am. Fish. Soc. Symp. 12:423–434.

Rawstron, R. R.
1971. Non-reporting of tagged white catfish, largemouth bass, and bluegills by anglers at Folsum Lake, California. Calif. Fish Game. 57:246–252.

Reinecke, K. J., C. W. Shaiffer, and D. Delnicki.
1992. Band reporting rates of mallards in the Mississippi alluvial valley. J. Wildl. Manage. 56:526–531.

Roberts Jr., D. E., B. V. Harpster, and G. E. Henderson.
1978. Conditioning and induced spawning of the red drum (*Sciaenops osellatus*) under varied conditions of photoperiod and temperature. Proceed. World Aqua. Soc. 9:311–332.

Ross, J. L., T. M. Stevens, and D. S. Vaughan.
1995. Age, growth, and reproductive biology of red drums in North Carolina waters. Trans. Am. Fish. Soc. 124:37–54.

Yeager, D. M., and M. J. Van Den Avyle.
1979. Rates of angler exploitation of largemouth, smallmouth, and spotted bass in Central Hill Reservoir, Tennessee. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 32:449–458.

Zale, A. V., and M. B. Bain.
1994. Estimating tag-reporting rates with postcards as tag surrogates. N. Am. J. Fish. Manage. 14:208–211.